# ENGINEERING NEWS
## AND
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FRAUDULENT EXPENDITURES IN CONSTRUCTING the new "Northwest" water-works tunnel at Chicago, Ill., are charged by the Citizens' Association, of that city, whose experts, Mr. S. S. Greeley and Mr. Geo. C. Prussing, have recently completed an examination of the work thus far completed. The more important specific charges made by the experts are: That the sectional dimensions of the tunnel have been decreased from 2 ins. to 12 ins. in places; that the section is irregular and the masonry and material poor; that for long distances four rings of brick have been paid for, when only three rings were built; that timber filling behind the masonry has been used when stone filling was contracted for, and this timber paid for as an extra, when extras were forbidden by the contract; that material has been classified and paid for as rock, which was only earth mixed with boulders, and that generally the specifications have been violated in other ways. The total sum for which the city is said to have been mulcted in the shape of unwarranted extras is given by the Citizens' Association at $69,120. In a formal reply to these charges, City Engineer Lewis B. Jackson asserts that all the changes made are allowed by clauses in the specifications, which give discretionary power to the City Engineer under certain conditions, and in all cases where extras were allowed and not thus provided for, it was done by the advice of the Corporation Counsel and the Mayor, and was balanced by certain concessions to the city on the part of the contractors. It is announced that the Citizens' Association proposes to carry the investigation further.

THE IMPROVEMENT OF THE NEW YORK WATER front has been again reported upon by Messrs. George S. Morison, Wm. H. Burr and William P. Craighill, the board of consulting engineers appointed by the Dock Board in December, 1895. This report is supplemental to one submitted on Feb. 6, 1896, and refers to the advantages of railway connection along the water front of New York city for the interchange of freight. The board regards an elevated railway as undesirable for this purpose, owing to the difficulties of handling heavy freight. It recommends a four-track surface road, with the two middle tracks kept open as main lines, to be operated by switching engines, but with no cars allowed to stand on these middle tracks. The two outer tracks would be used for standing cars, and connections made from them by spur tracks running to piers, warehouses, etc. The maximum width required would be 50 ft., and the board believes that this strip should be placed near the river, and a sufficient space left between the tracks and a 70-ft. wide street to permit teams to load on the cars without encroaching on the street, and it would be better to divide this space by a fence, with frequent gates, from the street proper. The report goes fully into the detail of the proposed loading of cars and handling of freight, but the full realization of benefits would require the abandonment of the water front now used by railways for holding cars on floats while loading and unloading. The plans of the board include marginal tracks along the North River front, from Battery Place to Christopher St., to be extended northward whenever room is available. On the East River conditions interfere, and a separate marginal system is suggested between Battery Place and Corlears Hook, with no connections other than by transfer boats and floats. The board also recommends the transfer of the street car traffic along West St. to an electric elevated railway, connecting with bridges for foot passengers at every cross street.

THE HOLLAND SUBMARINE BOAT was launched on May 17 from the shipyard of Lewis Nixon, at Elizabethport, N. J. The New York "Sun" describes this remarkable vessel as follows: She is 55 ft. long and 11 ft. in diameter, with a perfectly circular cross-section, with exceedingly strong frames and a skin made of ½-in. steel plates, so that she will be able to withstand the water pressure at a depth of 150 ft. and to bear sudden and heavy shocks and jars. The only entrance is through a turret on top, 28 ins. diameter and telescopic, so that the height can be extended from 8 ins. to 30 ins. This turret is watertight, and in the sides are long slits of glass, through which observations can be made. Inside she is divided into two compartments, the engine room and a working room. The latter is 12 ft. long by 10 ft. wide and about 5 ft. high; beneath it is the electric storage battery contained in a lead-lined steel case, weighing 46,000 lbs. and capable of furnishing 50 HP. for 6 hours, or 150 HP. for one-half hour. Into this chamber also opens the breeches of two dynamite guns and the torpedo expulsion tube, and here are located all the levers for working the mechanism of the boat. In the engine room is a 50 HP. gasoline engine, which will operate the single screw when the boat is traveling at the surface at a speed of about 8 knots. The electric motor, which is to be used when the boat is submerged, is capable of developing a speed of 14 knots in a spurt. There are two rudders, one vertical, of the ordinary type, and a horizontal rudder, intended to cause the boat to dive and to maintain a submerged course. Water tanks are used to keep the boat in trim, and ordinarily the craft will have a reserve buoyancy of about 1,000 lbs., giving a constant tendency to rise to the surface, which is only overcome by the horizontal rudders. For the 18-in. torpedo tube forward three automobile torpedoes will be carried. Above this tube is an 8-in. aerial torpedo-gun, capable of throwing an 80-lb. dynamite shell a distance of 1½ miles. Just above and parallel to the axis of the ship is a submarine 80-lb. dynamite gun pointing aft and capable of sending its shell 800 yds. under water at a high velocity. All of these guns are operated by compressed air and they have already been carefully tested under working conditions. The boat will carry 20 of the dynamite shells, besides the three automobile torpedoes. A crew of five men will be required, including the commander. One will sit at the commander's feet and work the levers; the third is an engineer, and two men will work the guns. Air will be supplied to the men from cylinders, and the foul air will be constantly exhausted by pumps, with an automatic device for constantly maintaining the air pressure inside at about 15 lbs. to the sq. in. at any depth below the surface. Other ingenious devices enable the commander to set his course under the water and to obtain the range of the enemy. Mr. Holland says that this boat is an improvement upon the one now being built by the government at Baltimore, being later in design ,though the Baltimore boat is larger, being 84 ft. in length, and is differently armed, and will run by steam when on the surface.

THE GUNBOAT "NASHVILLE," in her official trial trip on Long Island Sound, proved herself to be the fastest of her class by developing an average speed of 16.7 knots. This means a bonus of $60,000 to her builders, the Newport News Shipbuilding Co. The maximum screw revolution was 311.03 turns per minute, communicated without any perceptible jar. The new gunboat "Vicksburg," built at Bath, Me., has had a builder's preliminary run in a rough sea and developed a speed of 12½ knots per hour.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was caused by the collapse of a trestle near Ardmore, Ind. Ter., May 16. A southbound train of the Atchison, Topeka & Santa Fe Ry. was crossing when the trestle gave way, the foundations having been washed out by floods. The train consisted of an engine, tender, six day cars and a Pullman car; the engine and Pullman car remained on the track, but the other cars went down. Nobody was killed outright, but 15 persons were injured, some being fatally hurt.——A derailment occurred May 16 at the drawbridge which carries the Newark & New York branch of the Central R. R. of New Jersey over the Passaic River at Newark, N. J. The engine of an eastbound passenger train left the rails at the west end of the bridge, and the engine and four cars ran along the ties, the guard rails preventing them from going over the side of the bridge Nobody was hurt. It is supposed that in closing the bridge after the passage of a vessel the rail connections at the west end were not properly locked.

A LOCOMOTIVE BOILER EXPLOSION occurred May 14 on the Intercolonial Ry., at Richmond, N. S. The engine was standing in the roundhouse at the time. Nobody was hurt.

A SERIOUS RAILWAY ACCIDENT occurred in Russia May 13 between Rockenhof and Eliva, on the Valki-Jurjer line. A military train was passing over an embankment which had been submerged and damaged by the floods, when the embankment settled, causing the engine to leave the track, taking with it 15 cars filled with soldiers and two regular passenger cars. It is reported that 58 men were killed.

A HEAD COLLISION OF ELECTRIC CARS occurred May 14 on the Nassau Electric Ry., at Flatbush, N. Y. An empty car which was starting out to begin its trips was found to be out of order, and the men started back to the sheds on the same track, hoping to get back before the next car started. The morning was very foggy and in a few minutes the reversed car ran into the one which had been following it. The cars were telescoped and both motormen were seriously injured.

THE SPRAGUE SYSTEM OF ELECTRIC TRACTION, which has been adopted by the South Side Alley Elevated Railway, in Chicago, as announced last week, is now being tested by the Kings County Elevated Ry., of Brooklyn, with a view to its adoption. This company will eventually send its cars over the New York and Brooklyn Bridge to connect with the New York elevated system. The chief features of the Sprague system are that it substitutes for the electric locomotive two motors on one of the trucks of each car. A system of control is adopted, by which all the motors may be started and stopped and the cars braked by pressing a button located at any desired point throughout the train. The third rail system will be used in sections about 2,000 ft. long. A sub-feeder connects each end of each section with a main feeder running parallel with the track, which in turn is supplied with current at different points by feeders from the central station. With the Sprague system it is claimed that trains can be more quickly brought to full speed, since a larger percentage of the weight of the train is available for adhesion than with the locomotive system.

THE ELEVATION OF THE TRACKS OF THE Chicago & Northwestern and Pittsburg, Ft. Wayne & Chicago railways for 1½ miles along Rockwell St., in Chicago, Ill., will, it is stated, be begun about June 1. Each road has two tracks to raise, and while the elevation of one line is in progress the tracks of the other will be used to carry the traffic of both companies. The general method of construction will be like that followed in the previous track elevation work of the Chicago & Northwestern as described in Engineering News of Aug. 20, 1896. Altogether the work will entail the construction of 10 subways for crossing streets. Two elevated railway lines and six surface street railways will be crossed. The work for both companies will be in charge of Mr. L. H. Evans, M. Am. Soc. C. E., Engineer of Track Elevation, Chicago & Northwestern Ry. This will be the first work of track elevation done by the Pennsylvania Co. in Chicago and the third line elevated by the Chicago & Northwestern Ry.

PROPOSALS FOR THE EXPERIMENTAL MODEL tank and building, to be erected at the Washington Navy Yard, have been advertised for by the Secretary of the Navy. Plans and specifications and other information for bidders will be furnished by the Bureau of Construction and Repair, Navy Department. Bids will be opened on June 7. The building is to be about 500 by 50 ft.

THE MEXICAN NAVIGATION & RAILWAY COMPANY was incorporated in the City of Mexico, on May 3, to build a railway from a suitable point on the National Tehuantepec Railway to some point in Vera Cruz. With the concession is given a subsidy of about 8,000 acres of land per kilometre of railway constructed. Upon about 400,000 acres of this land the company will settle European and other colonists.

A MECHANICAL FILTER PLANT of the Jewell type has just been installed at Lorain, O., under a guarantee to remove 97% of the bacteria in the applied water. According to the Lorain "Herald," examinations by Dr. A. J. Baumhardt, Bacteriologist to the local board of health, showed an average removal of 97.61% for 22 days in March last, the average number of bacteria in the applied water being 3,725, and in the filtrate, 88 per cu. cm. No examinations were made on Sundays, nor on two days when the supply of coagulant was exhausted, and on three days the count could not be made, owing to the liquefaction of the gelatine. On six days of the 22 the bacterial reduction was a little under 97%, but never below 96%. The remaining 16 days it was above 97%, exceeding 98% on eight days and reaching 99.17% one day. On three days the number of bacteria in the effluent exceeded 100 per cu. cm., always when the original number was above the average, the greatest number being 10,976 in the crude water and 418 in the filtrate. On five days the number of bacteria in the effluent was below 50 per cu. cm.

BIDS FOR ASPHALT PAVING STRIPS FOR BICYclists in Brooklyn have just been submitted. There were only two bidders, the Eastern Bermudez Co. offering to do the work for $1.30 per sq. yd., and Cranford & Co. asking $1.50. The present granite block pavement, which rests on a sand or dirt foundation, will be lowered 2 or 3 ins. and the asphalt, 5 ft. in width, placed on the blocks.

## THE FRAMES OF THE "KAISER FRIEDRICH."

We reproduce from our German contemporary, the "Zeitschrift des Vereines Deutscher Ingenieure," the accompanying cut showing the frames of a new transatlantic steamer, the "Kaiser Friedrich," which has been built for the North German Lloyd Steamship Co. by F. Schichau, of Danzig, Germany, the manufacturer whose triple expansion engine direct connected to a Siemens-Halske dynamo won so much admiration from American engineers at the Columbian Exposition. The new vessel will rank with the largest and swiftest of the transatlantic greyhounds. Her principal dimensions are given by our contemporary as follows:

| | Meters. | |
|---|---|---|
| Length over all | 182.6 | (599 ft. 1 in.) |
| Length bet. perpendiculars | 176.8 | (580 " 0¾ " ) |
| Beam | 19.5 | ( 63 " 11¾ ins.) |
| Depth on the side | 12.5 | ( 41 " 0 " ) |
| Depth of hull | 11.525 | ( 37 " 9¾ " ) |
| Draft, about | 8.35 | ( 27 " 4¾ " ) |

This steamer is being built in accordance with the highest class specifications of the German Lloyd. The two engines are rated at 28,000 HP., and the speed at 21 knots. With a displacement of 17,500 tons, the carrying capacity is 4,900 tons and the cubical contents 12,500 register tons.

Our engraving is especially interesting as showing the great depth of the vessel in proportion to her width near the bow, and will give, we presume, to some of our readers a clearer idea of the structure of a modern steel vessel than they have before possessed.

## THE PARSONS STEAM TURBINE APPLIED TO MARINE PROPULSION.

In a paper read before the British Institution of Naval Architects, in April, by the Hon. Charles Parsons, the inventor of the Parsons compound steam turbine, he described the application of the turbine to marine propulsion in a torpedo boat called the "Turbinia." The following is an abstract of the paper:

In the year 1892 a highly developed compound turbine, adapted for condensing, when tested by Professor Ewing, F. R. S., showed a consumption of steam equivalent to 15.1 lb. per I. HP. per hour, the boiler pressure being 100 lbs., and the steam superheated to 127° F. above the point of saturation. More recently, compound turbine engines have been constructed up to 900-HP., both condensing and non-condensing, and consumptions of steam as low as 14 lbs. per I. HP., with saturated steam, and 100 lbs. boiler pressure have been ascertained in engines of 200-HP., and still lower consumption in engines of larger size. Many of the original engines are still doing good work; some, especially the larger sizes of 500-HP. and upwards, are frequently kept at work for several weeks without stopping. The total horse-power of turbines now at work in England exceeds 30,000-HP.

In January, 1894, a syndicate was formed to test thoroughly the application of the compound steam turbine to marine proulsion, and a boat was designed for this purpose. It was decided to keep the dimensions as small as possible, but not so much as to preclude the possibility of reaching an unprecedented rate of speed, should all the parts work as satisfactorily as was anticipated. The fulfilment of these anticipations was, however, much delayed, and almost frustrated, by a difficulty which, though foreseen, proved to be of a much more serious character than was anticipated. This difficulty was that termed by Mr. R. E. Froude "the cavitation of the water," or, in other words, the hollowing out of vacuous spaces by the blades of the screw, and the pitfall for the designers of screws for very fast vessels, though indicated by theory to exist, came upon us in the case of our very fast running screw, taxed beyond the usual extent, in its most aggravated form. When the boat and the machinery were designed the trials of the "Daring," which first drew attention to this difficulty, had not taken place.

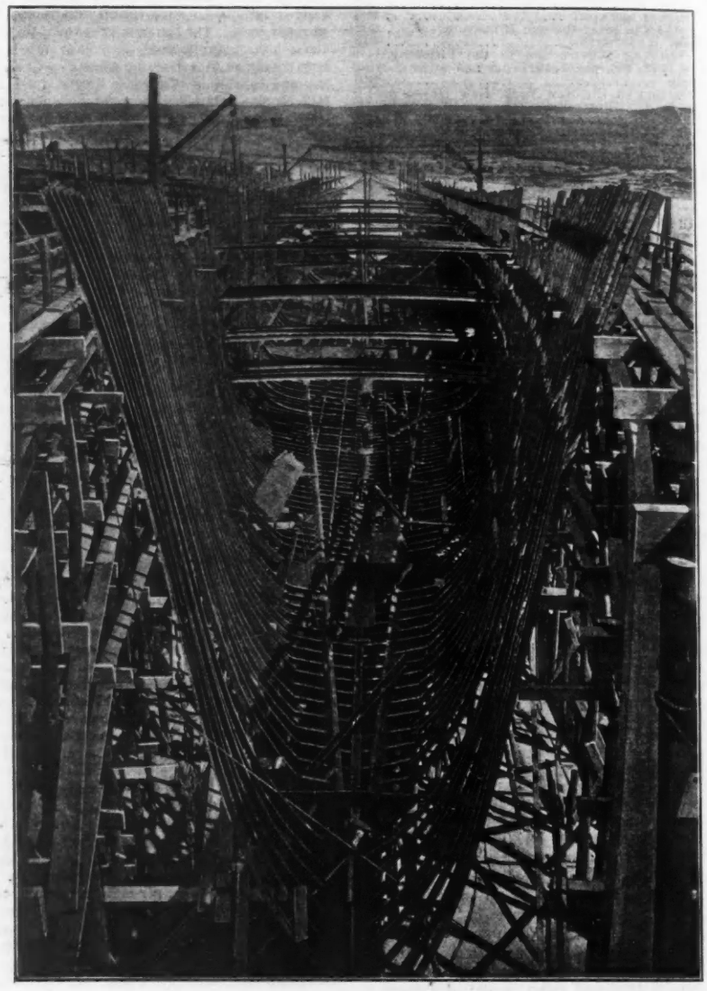
The "Turbinia"—as the boat is named—is 100 ft. in length, 9 ft. beam, and 44½ tons displacement. The approximate weights are: Main engines, 3 tons, 13 cwt.; total weight of machinery and boiler, screws and shafting, tanks, etc., 22 tons; weight of hull complete, 15 tons; coal and water, 7½ tons; total, 44½ tons. The original turbine engine fitted in her was designed to develop upwards of 1,500 actual HP. at a speed of 2,500 revs. per minute. The boiler is of the water-tube type, for 225 lbs. per sq. in. working pressure, with a total heating surface of 1,100 sq. ft., and a grate surface of 42 sq. ft. The stokeholds are closed, and the draught furnished by a fan. The condenser has 4,200 sq. ft. of cooling surface.

Trials were made with screws of various patterns, but the results were unsatisfactory, and it was apparent that a great loss of power was taking place in the screw. To investigate the question thoroughly, a spring torsional dynamometer was fitted between the engine and screw shaft, measuring the actual torque transmitted. The measurements proved that the cause of failure lay entirely in the screws, and, with the object of further investigating the character of this waste of power, a series of experiments were made with model two-bladed screws of 2-in. diameter, revolved in a bath of water heated to within a few degrees of the boiling point, and, in order that the model screw should produce analogous results to the real screw, it was arranged that the temperautre of the water and the head of water above the propeller, as well as the speed of revolution, should be such as to closely resemble the actual conditions and forces at work in the real screw, the object in heating the water being to obtain an increased vapor pressure from the water, so as to permit a representation of the conditions with a more moderate and convenient speed of revolution than would otherwise have been necessary.

The screw was illuminated by light from an arc lamp reflected from a revolving mirror attached to the screw shaft, which fell on it at one point only of the revolution, and by this means the shape, form and growth of the cavaties could be clearly seen and traced as if stationary. It appeared that a cavity or blister first formed a little behind the leading edge, and near the tip of the blade; then as the speed of revolution was increased, it enlarged in all directions until, at a speed corresponding to that in the "Turbinia's" propeller, it had grown so as to cover a sector of the screw disc of 90°. When the speed was still further increased, the screw, as a whole, revolved in a cylindrical cavity, from one end of which the blades scraped off layers of solid water, delivering them on to the other. In this extreme case nearly the whole energy of the screw was expended in maintaining this vacuous space.

From these experiments it would appear that in all screws, of whatever slip ratio, there will be a limiting speed of blade, depending upon the slip ratio and the curvature of the back—in other words, on the slip ratio and thickness of blade; beyond this speed a great loss of power will occur; and that, should the speed of ships be still further increased, the adoption of somewhat larger pitch ratios than those at present usual will be found desirable.

The single compound turbine engine was now removed from the boat and replaced by three separate compound turbines, directly coupled to three screw shafts, working in series on the steam, the turbines being the high pressure, intermediate, and low-pressure, and designed for a complete expansion of the steam of 100-fold, each turbine exerting approximately one-third of the whole power developed. The total weight of engines and the speed of revolution remained the same as before. The number of



THE HULL FRAMING OF THE TRANSATLANTIC STEAMER "KAISER FRIEDRICH," OF THE NORTH GERMAN LLOYD STEAMSHIP CO.
From a Photograph taken in the Shipyard of F. Schichau, Dantzic, Germany.

gravity of the machinery is consequently much lower than with ordinary engines.

At all speeds the boat travels with an almost complete absence of vibration, indeed the "Turbinia" has so far proved herself an excellent sea boat. The oiling of the main engines is carried on automatically by a small pump worked off the air-pump engine. The main engines require practically no attendance beyond the regulation of a small amount of live steam to pack the glands and keep the vacuum good.

The advantages claimed for the compound steam turbine over ordinary engines may be summarized as follows: (1) Increased speed, (2) increased economy of steam, (3) increased carrying power of vessel, (4) increased facilities for navigating shallow waters, (5) increased stability of vessel, (6) increased safety to machinery for war purposes, (7) reduced weight of machinery, (8) reduced space occupied by machinery, (9) reduced initial cost, (10) reduced cost of attendance on machinery, (11) diminished cost of upkeep of machinery, (12) largely reduced vibration, (13) reduced size and weight of screw propellers and shafting.

### Trials of the "Turbinia."

In December, of last year, several runs were made on the measured mile, and the maximum mean speed obtained

after due allowance for tide was 29.6 knots per hour, the mean revolutions of the engines being 2,550 per minute. Since then new propellers of increased pitch ratio have been fitted. Further trials were made on April 1. The means of the two consecutive runs gave a speed of 31.01 knots per hour, the mean revolutions of the engines being 2,100 per minute, the fastest run being at the rate of 32.61 knots per hour. The utmost horse-power required to drive the boat at the speed of 31.01 knots is 946, as calculated from experiments on her model, made at Heaton Works, on the method of the late Mr. William Froude.

Assuming the ratio of thrust HP. to I. HP. to be 60% the equivalent I. HP. for 31.01 knots is 1,576. The feed-water consumption at 31.01 knots is approximately 25,000 lbs. per hour, or 15.86 lbs. per I. HP.

Conditions of Running of "Turbinia" at 31.01 knots speed.

| | |
|---|---|
| Mean revolutions of engines | 2,100 |
| Steam pressure in boiler, lbs | 200 |
| Steam pressure at engines, lbs | 130 |
| Vacuum at exhause of engines, lbs. | 13½ |
| Speed of boat, knots | 31.01 |
| Calculated thrust horse-power | 946 |
| Calculated indicated horse-power | 1,576 |
| Consumption of steam reduced to basis of 31.01 knots, lbs | 25,000 |
| Consumption of steam per I. HP. per hour, lbs. | 15.86 |
| Total weight of machinery, in working order, tons | 22 |
| Indicated horse-power per ton of total machinery. | 72.1 |

On April 10,, 1897, the "Turbinia" attained the highest velocity ever reached by a steam vessel, making an average of 32¾ knots on the measured mile.

## ECCENTRIC LOADS ON FOUNDATIONS.

By F. L. Douglas.

The necessity of utilizing the greatest possible proportion of space in the crowded sections of large cities, requires that the outside walls of buildings be built out to the boundary lines of the lots. In order to get sufficient area at the bottom of the foundations to reduce the pressure on the earth per unit of area to a safe limit, the footing courses are made wider by extending them inside toward the center of the building, the limits of the lots preventing any extensions in the opposite direction. The result is, that the center of the load which is very near the center of the wall, is not over the middle line of the bottom footing course of the wall. An overturning tendency will result, as can readily be seen, that part of the footing under the outside wall line tending to go down, and the inner edge, or toe of the footing, tending to rise. In order that the wall be stable, the several forces must become equalized in some way, and this condition must be effected by increasing the pressure per unit of area under the heel of the footing and decreasing the pressure under the toe, until the center of gravity of the resulting trapezoid of resistance of the earth is brought directly under the center of gravity of the load from above.

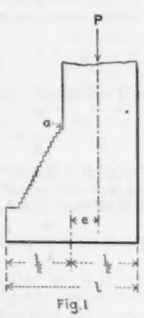


Fig. 1

The purpose of this article is to show an easy method for obtaining this maximum pressure under the heel of the footing, and applies to all cases where footings rest directly upon the earth, and also where grillage beams are used to distribute the loads over greater areas, and when slightly modified may be used in obtaining the proportion of total load carried by each of the several lower grillage beams, when the loads are not symmetrically placed.

We will consider a cross-section of the wall one foot in length.

Let P = total load per lineal foot on foundation.

l = width of footing at bottom in feet.

A = Average pressure on ground in tons, per sq. foot, equal $\frac{P}{l}$

e = eccentricity = distance in feet between the center of pressure in wall and center of lower footing course.

M = maximum pressure in tons per sq. ft. on ground.

The formula for maximum pressure is,

$$M = A + 6\,A\,\frac{e}{l}$$

The force diagram representing the upward pressure of the earth upon the footing may be represented by the trapezoid A B C D, Fig. 2. Produce B C to E, meeting E F drawn parallel to A B through O, the middle point of C D.

If the center of the wall were to be placed over the center of the footing, the force diagram would be represented by the rectangle A B E F; but since the center of the footing is not under the center of the load, a couple is produced equal to Pe. To resist this couple, the force diagram will change from a rectangular to a trapezoidal form, by taking away the force represented by the triangle C O E from one side and adding the equal force represented by the triangle D O F to the other, producing a couple which will be equal in amount and opposite in direction to Pe; otherwise the forces would not be in equilibrium.

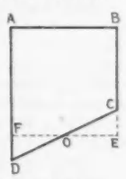


Fig. 2.

$\frac{P_e}{2}$ = Moment of force represented by one triangle.

$\frac{1}{2} \times \frac{2}{3} = \frac{1}{3}$ = Lever arm of same force.

$\frac{P_e}{2} \div \frac{1}{3} = \frac{3\,P_e}{2l}$ = Amount of force represented by one triangle.

$\frac{3P_e}{2l} \div \frac{1}{2} = \frac{6\,P_e}{2l^2}$ = Intensity of force at middle of triangle.

$\frac{6P_e}{2l^2} \times 2 = \frac{6P_e}{l^2}$ = Intensity of force at edge of triangle.

Total intensity of force at edge of footing then will be

$$\frac{P}{l} + 6\,\frac{P_e}{l^2} = A + 6A\,\frac{e}{l} = \text{maximum load per square foot.}$$

This formula applies only to those cases where the center of the load falls within the middle third of the base which, however, should always be the case. It is evident that as soon as the foundation begins to adjust itself to the eccentric load, the compression increases on the inside of wall, and decreases on the outside. If greater refinement in calculations is desired, we may first consider the brickwork of the wall to be loaded up to its safe limit, at the point A in Fig. 1, where it would be the maximum.

By making M in above formula equal to the safe compressive strength of the brickwork and solving the equation for e, we can obtain the center of gravity of the load when limit of compression on brickwork is reached. The distance between this line and the center of the footing will be the e to use in formula to determine the maximum pressure on the earth.

## OPERATION OF THE SEWAGE FILTER BEDS OF BROCKTON, MASS., IN 1896.

In our issues of May 2 and 23, 1895, we described in detail the construction of the sewage disposal works of Brockton, Mass., where the sewage is pumped to filter beds and subjected to intermittent filtration. The operation of the beds during 1895 was reviewed in our issue of Feb. 27, 1896. The information previously presented was obtained through the courtesy of Mr. F. Herbert Snow, City Engineer of Brockton, who has been engineer of the whole city sewerage system since construction was begun in 1893. Mr. Snow has kindly sent us an advance copy of his report for 1896, from which we have abstracted the information given below regarding the operation of the filter beds during 1896.

Mr. Snow is far more fortunate than most engineers who construct sewage purification plants in that the operation of the system which he designed and built remains in his charge after being put in operation, he, as city engineer, being ex-officio superintendent of the sewerage department. He is still farther fortunate in the fact that the board of sewerage commissioners shares his broad views of the way the system should be managed, making it possible to conduct studies of the operations of the filter beds which will prove of great value, both as a guide to the sanitary and economical administration of these particular purification works and as contributing greatly to the common stock of knowledge on the subject. The section of Mr. Snow's report relating to the filter beds was written by Mr. F. A. Barbour, Chemist in charge of the beds.

The filtration area covers about 30 acres, divided into 23 beds. The population of Brockton in 1890 was 27,294. The estimated population connected with the sewers at the close of 1896 was only about 5,000, being an increase of some 2,000 in a year. During the last quarter of 1896 the total water consumption of all buildings connected with the sewers, as shown by the meters, was 9,962,000 gallons, or a little over 100,000 gallons a day. Adding 25% for water entering the sewers through connections, but not shown by meters, gives 125,000 gallons a day delivered to the street sewers in December, against an actual discharge of 559,000 gallons, thus showing a leakage of over 400,000 gallons a day, on about 16 miles of sewers, or 25,000 gallons per mile. Regarding this leakage Mr. Snow states in the portion of the report written by him that it affords no greater flow through the sewers than is needed to keep them clean, the present volume of sewage being small as compared with the capacity of the sewers. When the volume of sewage increases so as to make the leakage a serious matter, he repeats the suggestion made some time ago, that means can then be taken to reduce the leakage, first of all by improving natural water channels so as to facilitate surface drainage.

The actual quantities of water passing through different classes of meters is interesting. The consumption by 154 private dwellings was 1,521,000 gallons in three months, or 107 gallons each per day; 128 business blocks, apartment houses, etc., used 5,425,000 gallons, or 461 gallons each per day; 27 factories used 3,016,000 gallons, or about 1,200 gallons each per day.

As would be expected with so small a water consumption as that of Brockton, one of the lowest in the country, the analyses of the crude sewage show an unusually high per cent. of solids, but before reaching the beds it is subjected to a considerable amount of sedimentation in the receiving reservoir, especially as the present small volume of sewage enables the pumps to handle it in a short time, leaving all the remaining time for settlement; the sewage is also pumped through a long force main to the beds. The sedimentation and pumping, together with the decomposition that takes place during the time consumed in each process, reduce the organic matter, as shown by the albuminoid ammonia, by about 45%. This figure, however, is only approximate, being partially estimated.

The sludge, as well as the sewage, is pumped to the filter beds, the sludge being confined to nine beds. The total amount of both sewage and sludge pumped in 1896 was 180,200,000 gallons, or an average of 500,000 gallons per day. Of this, 25,000,000 gallons was sludge, which after being deposited on the beds, draining and drying, was removed by raking and scraping to the amount of 145,000 lbs. After removal the sludge was burned. The total cost of removing and burning the sludge was $440, or $17 per 1,000,000 gallons of sludge applied, or $2.05 per 1,000,000 gallons of both sewage and sludge; that is, of the total volume received and handled at the pumping station.

In May, June, July and August the sludge beds were cropped and practically no raking done, these beds receiving at the same time the total sewage flow. During the balance of the year the beds were raked at greatly varying periods, from once every two doses to only once in ten doses, the latter being in winter, and the average being one raking for every four doses.

Pumping the sludge has the effect of finely dividing it, and thus increasing its penetration into the beds. This penetration, however, is reduced by the formation of a layer of paper over the sand. It is believed that the organic matter is mostly confined to the upper 2 ins. of the bed.

Analysis of the sludge deposits removed from the beds showed 33%, by weight, of water, 41% of ashes and gravel and 26% of organic matter.

The general conclusions presented in the report regarding the operation of the sludge beds are as follows:

So far it appears that the best way to handle sludge is determined, and even prescribed, by the senses of sight and smell. With underdrains at a considerable depth and distance apart, the appearance and odor of a sludge bed will demand attention before the effluent shows any difference. This applies, of course, only within the limits of proper management and system of dosing.

The preceding remarks regarding the care of beds relate only to those receiving sludge. The only work done on the beds receiving sewage was weeding and furrowing.. To keep the weeds down the beds must be gone over about once a month during the summer, or perhaps five times in the year, at a cost of about $2 a bed for each weeding. The furrowing was done in November by a one-horse cultivator. The furrows are made to lessen the effect of frost on the beds.

The report gives the cost of caring for the surface of each bed during each month of the year, but owing to the small quantity of sewage treated, as compared with the available area, and the fact that many of the beds were not used at all during the summer, although work was put on them to keep down the weeds, it does not seem advisable to give these figures.

Quite a variety of crops were planted on the beds receiving both sludge and sewage, but most of these were confined to small areas on one bed, and in such a manner that the cropping was almost wholly experimental, in these cases. The crops on small areas were confined to Bed No. 4, and included peas, beans, tomatoes, sweet corn, cabbages and turnips. The report gives the detailed results in each case, with cost and revenue, actual or estimated. We shall mention only some of the conclusions regarding the various crops. Peas and beans would probably do best planted on level beds, rather than on mounds, so the sewage would wet about 2 ins. of the vines. The peas planted were a success, and were sold to one of the leading hotels in the city, but the beans were a failure. Sweet corn should be planted 4 ft. between rows and 3 ft. between hills. It will probably take a large amount of sewage, demand but little attention and yield some profit. Tomatoes would also have the lower parts of the vines wet with sewage. Cabbages require more care than sweet corn and if sludge is applied the surface of the bed must be raked, the same as when a bed is not cropped. Regarding turnips, it is thought that on a coarse sand or gravel bed a level surface and large doses of sewage should be employed, while in a heavier soil small doses and a ridged surface will give the best results. Considerable moisture appears to be needed during the early growth of turnips and but little after the root is formed.

Six beds were planted with field corn (Longfellow) on May 10. The seed was put in with a one-horse planter, 12 quarts per acre being used. The rows were nominally 3 ft. apart and the hills 18 ins., but should have been 3½ ft. between rows and 2 ft. between hills. The corn was cultivated on June 1, and again about July 1, with a horse hoe. The corn did well, but the yield of only one bed is known. Here 144 bu. of ears per acre, or about 70 bu. of shelled corn, were obtained. Between May and September about 11,000,000 gallons of sludge (amount of sewage in addition not stated in the report) was applied to these six beds without raking, which would otherwise have been necessary. The actual cost of the crop, including planting, cultivating and removing stubble, was $103. The corn was sold at auction for $9 per bed, or $54, leaving the net cost of the crop $49. But had not the beds been planted they would have required raking. Estimating the cost of raking on the basis of the experience gained when the beds were not in crops, a net gain of $201 is shown for the crops. Had not the stubble been removed the total cost of the crop would have been only $23, leaving $26 clear, without allowing for the saving in raking. The report states that the stubble is commonly left on other filtration beds, and that this may do in coarse gravel, "but with a fine sand or subsoil the accumulation of organic matter should be prevented as far as possible."

The general conclusions regarding crops of sewage filter beds are given in the report as follows:

The deduction thus far is that while the crops paid for themselves, no advantage in handling sludge, or perhaps better stated the insoluble albuminoid ammonia, can be claimed for a bed planted with garden truck over one not planted. This advantage, as has been shown, amounts to considerable with corn beds, effecting a saving in our case of an estimated amount of $250. With the garden truck as managed this year rather the contrary is the result. This is largely due to excessive care taken to keep the bed looking neat.

As to the general value of cropping filter beds an unconditional answer is impossible from our limited experience. The nature of the soil and method of handling the sludge must largely determine its advisability. The inevitable result of cropping must be to increase the organic matter and more or less clog the bed, making the time of absorption longer and perhaps increasing the tendency to freeze in winter. With a coarse sand or gravel the increased time of absorption may be undesirable.

The best and most economical material for a filtration area of small extent is clean sand, and sand is at its best—unless very coarse—when it contains the least amount of organic matter. Any course of treatment tending to limit its capacity must have counterbalancing advantages, to be recommended.

It is noticed that the sewage disappears more slowly from the surface of the cropped beds this winter than it did a year ago. Whether this is due to the cropping or to insufficient depth of furrows has not yet been determined.

With the sludge applied to the land as in our case, it is believed that, in summer, cropping affords a valuable method of handling the sludge with little work and no odor or unsightly appearance. This disappearance of the sludge and paper during the growth of corn is really remarkable; practically nothing but stubble was removed in cleaning up the beds for winter.

The supernatant liquid of settled sewage can be handled without difficulty at all seasons of the year, and leaving out the handling of the sludge it is a question whether it is best to plant beds which receive only this liquid.

The rate of applying sewage to the beds is thought to be an important factor, and one that should always be given in stating the daily rate of filtration. During the year the average rate of application at Brockton was 3,700 gallons per minute per bed. At this rate, even on coarse sand, a dose of 100,000 gallons will acquire a depth of 3 ins. over the entire bed in the time necessary to apply it.

The degree of purification effected by the beds from May to December, 1896, inclusive, as shown by comparing the calculated strength of the sewage with that of the effluents from the 12 and 15 in. underdrains was about 98%, as shown by the decrease in albuminoid ammonia, commonly taken as representing the organic matter.

As already intimated, any figures regarding the cost of operating the beds are likely to be misleading, on account of the comparatively small amount of sewage treated and the low rate of filtration per acre. Omitting capital charges and chemist's salary, the total expense of filtering 180,000,000 gallons of sewage was $2,195, or $12 per 1,000,000 gallons. The sewerage commissioners of Brockton are as follows: Wm. L. Douglas, Chairman, A. Cranston Thompson and Walter F. Cleaveland.

WEATHER TABLE FOR APRIL, 1897. (Furnished to Engineering News by the Department of Agriculture.)

| | Stations. | Temperature. (Degrees Fahrenheit.) Average. | Max. | Min. | Range. | Wind. Velocity in miles per hour. Average. | Max. | Direction at time of max. velocity. | Precipitation—rain or melted snow—inches. Total. | Heaviest in 24 hours. | No. of rainy days. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Northern Cities. | Northfield, Vt. | 41.4 | 82 | 12 | 70 | 9.2 | 46 | SW | 2.73 | .77 | 14 |
| | Portland, Me. | 43.8 | 71 | 17 | 54 | 8.1 | 32 | S | 2.60 | 1.07 | 11 |
| | New York City. | 48.6 | 74 | 24 | 50 | 13.5 | 58 | NW | 2.96 | 1.21 | 9 |
| | Pittsburg, Pa. | 51.0 | 81 | 26 | 55 | 7.0 | 34 | SE | 3.34 | 1.08 | 15 |
| | Chicago, Ill. | 46.0 | 78 | 24 | 54 | 20.4 | 67 | S | 2.23 | .54 | 18 |
| | Omaha, Neb. | 50 5 | 79 | 29 | 50 | 10.4 | 35 | NW | 5.67 | 1.47 | 14 |
| | St. Paul, Minn. | 45.8 | 78 | 23 | 55 | 9 5 | 40 | NW | 1.56 | .59 | 11 |
| | Duluth, Minn. | 4o.0 | 78 | 14 | 64 | 11.7 | 44 | SW | .72 | .36 | 9 |
| | Bismarck, N. Dak. | 42.2 | 81 | 19 | 62 | 10.6 | 47 | NW | 1.40 | .86 | 9 |
| | Average. | 45.5 | 78 | 21 | 57 | 11.2 | 45 | | 2.58 | .88 | 12 |
| Southern Cities. | Washington, D. C. | 52.9 | 88 | 29 | 59 | 7.8 | 35 | NW | 3.02 | 1.84 | 11 |
| | Louisville, Ky. | 55.4 | 88 | 28 | 60 | 10.2 | 32 | S | 3.83 | 1.19 | 13 |
| | St. Louis, Mo. | 56.0 | 80 | 35 | 45 | 12.6 | 43 | E | 4.66 | 1.54 | 14 |
| | Savannah, Ga. | 66.2 | 85 | 45 | 40 | 9.6 | 36 | NE | 3.35 | 1.57 | 11 |
| | Kansas City, Mo. | 54.7 | 84 | 35 | 49 | 10 9 | 36 | S | 2.57 | 1.04 | 7 |
| | Jacksonville, Fla. | 69.0 | 88 | 44 | 44 | 8.5 | 46 | S | 5.18 | 1.85 | 12 |
| | Chattanooga, Tenn. | 59.5 | 85 | 36 | 49 | 8.1 | 37 | SW | 4.18 | 1.31 | 12 |
| | New Orleans, La. | 68.0 | 84 | 50 | 34 | 9.6 | 36 | W | 5.75 | 1.86 | 9 |
| | Memphis, Tenn. | 61.4 | 84 | 42 | 42 | 10.9 | 40 | NW | 5.46 | 1 39 | 15 |
| | Palestine, Tex. | 66.1 | 86 | 41 | 45 | 7.8 | 26 | W | 2.01 | .87 | 9 |
| | Average. | 60 9 | 85 | 38 | 47 | 9.6 | 37 | | 4.00 | 1.40 | 11 |
| Western Cities. | Helena, Mont. | 45.2 | 77 | 26 | 51 | 8.7 | 36 | NE | 1.15 | .51 | 11 |
| | Port Angeles, Wash. | 46.8 | 66 | 30 | 36 | 6.7 | 36 | W | .48 | .37 | 7 |
| | San Francisco, Cal. | 57.4 | 84 | 45 | 39 | 11.3 | 35 | W | .27 | .20 | 3 |
| | Salt Lake City, Utah. | 49.0 | 80 | 26 | 54 | 7.2 | 40 | N | 2.00 | .99 | 11 |
| | Santa Fe, N. Mex. | 47.2 | 72 | 24 | 58 | 8.0 | 40 | NW | .87 | .62 | 7 |
| | Denver, Colo. | 47.4 | 77 | 15 | 62 | 8.9 | 46 | SW | 1.31 | .48 | 11 |
| | Yuma, Ariz. | Discontinued | | | | | | | | | |
| | Average. | 48.8 | 76 | 28 | 50 | 8.5 | 39 | | 1.01 | .53 | 8 |

## THE THEORY OF THE IDEAL COLUMN.

The following papers by Professors Merriman, Dubois and Johnson were prepared as comments upon the paper with the above title by Mr. Henry S. Prichard, M. Am. Soc. C. E., published in our issue of May 6.

### Discussion by Professor Mansfield Merriman.

The fundamental idea in Mr. Prichard's paper is to give a mathematical discussion of the ideal column; that is, of a column initially straight, subject to axial load, and of homogeneous material. As he remarks, most of the conclusions are well known, and yet it seems desirable to develop and illustrate them in view of the fact that uncertainty exists in the minds of some engineers regarding their validity. The paper will be of particular value in correcting the erroneous impression that Euler's formula neglects the direct compression due to the load, and of clearing the way for the establishment of a rational formula for columns as they actually exist in practice.

The modification of Euler's formula proposed by Mr. Prichard, although apparently of little practical importance, is one of much theoretical value, because the strict discussion of a column in indifferent equilibrium requires the consideration of the smallest details. While this modification has been given before by Winckler and by Grasshof, the manner in which Mr. Prichard has developed it is new and simple. This method will undoubtedly be further extended so as to deduce important facts, and I here note the results of a recent investigation. Let $l$ be the original free length, $l_1$ the length after compression, and $l_2$ the length of the chord of the deflected curve. Then I find that Euler's modified formula will be, for round-ended columns,

$$\frac{P}{A} = \frac{\pi^2 E r^2 l_1}{l\, l_2^2}$$

and expressing $l_1$ and $l_2$ in terms of $l$ this reduces to

$$\frac{P}{A} = \frac{\pi^2 E r^2}{l^2} + \frac{P^2}{A^2 E} + \frac{P^2}{A^2 E}\,\frac{\Delta^2}{2 r^2}$$

in which $\Delta$ is the maximum deflection. Now, as the first term of the second member is a close approximation to the value of $P \div A$, this becomes

$$\frac{P}{A} = \frac{\pi^2 E r^2}{l^2}\left(1 + \pi^2 \frac{r^2}{l^2} + \frac{\Delta^2}{2 l^2}\right)$$

which is not only more accurate than Euler's original formula but shows new deductions. It indicates that the load P, required to hold the column in the deflected curve, really increases with the deflection $\Delta$. Further it shows that the deflection is not really indeterminate for failure by lateral flexure under ideal conditions.

Conclusion 4, as given by Mr. Prichard, does not seem entirely sound for the ideal column whose treatment must be purely mathematical. Formula (16) gives the two values derived from (15), namely,

$$\frac{W}{A} = S_B \text{ and } \frac{W}{A} = \frac{\pi^2 E r^2}{l^2}$$

but it is not clear to me that the first value belongs to columns whose lengths are less than a certain limit and that it cannot apply to lengths exceeding this limit. The ideal column knows no such distinction regarding length, but the distinction is simply one between bending and not bending. If it does not bend the first value of $\frac{W}{A}$ is correct; if it does bend the second value is correct. With actual columns, of course, the length is an important element in determining the question of bending, but this is because they are not initially straight or are not homogeneous, that is, because they are not ideal columns.

Turning now from the ideal to the actual column it is seen that Mr. Prichard gives but a single formula for the latter, namely (19), and presumably this is the practical formula to which he gives preference. As this formula

has received much attention since the publication of the article on "The Rational Design of Columns" in Engineering News of July 19, 1894, it seems desirable to state here facts about its history which were unknown to me then. Writing S in place of the $S_e$ of Mr. Prichard, this formula is

$$\frac{W}{A} = \frac{S}{1 + \frac{S}{m\pi^2 E}\frac{l^2}{r^2}} \qquad (19)$$

in which S is any unit-stress less than the elastic limit of the material, and m is 1, 2¼, or 4 according to the arrangement of the ends, while W is the safe load that produces the unit-stress S.

This formula (19) has, as a recent search has shown, been proposed by a number of writers. It appears in Grashof's Elasticitaet und Festigkeit (Berlin, 1878), and also in an article by Hatzel, translated in Van Nostrand's magazine in 1877 by T. H. Johnson. Crehore's deduction and discussion appears also in Van Nostrand's magazine for 1879. The same formula, with S instead of $\pi^2$, is again developed by Krohn in Transactions of American Society of Civil Engineers for 1886. It appears that the investigations of these authors were entirely independent, and that all have regarded it as a rational formula deduced from the principles of mechanics and not as an empirical formula derived to fit certain experiments.

Lately this formula has been advocated by Prof. Du Bois and others, while the paper of Mr. Prichard, now before us, tends to still further establish it as a valid rational formula for practical use. Until very lately I have held the view that it embodies the elements of rationality more than any other formula. A recent review of the subject, however, has led me to the conclusion that it contains a serious defect, the error being the more serious the longer the column, and that hence it is important to correct the error before the formula gains wider acceptance.

The defect in (19) becomes apparent if we consider a column so long that 1 in the denominator of the formula may be neglected in comparison with the other term; then it becomes

$$\frac{W}{A} = \frac{m\pi^2 E r^2}{l^2}$$

which is the condition of failure by bending, whereas it should be a condition of stability. In fact, Euler's formula is always the criterion of failure, and it seems that all rational formulas derived by making a line or curve tangent to Euler's curve are defective in establishing a proper formula for the case of stable equilibrium. If S becomes the elastic limit $S_e$, formula (19) is a good one for cases of failure, as Mr. Prichard has pointed out. For cases of practical design it is a good one for short columns, but for long columns it fails to secure stability.

The question now arises whether it is possible to establish a rational formula for the actual column which shall avoid this difficulty. This may be done on the same lines of reasoning as in my paper of 1894, by using Euler's formula and the corresponding curve for the condition of stability instead of that of failure, and always keeping fast to the fundamental requirement that the maximum unit-stress shall not exceed the elastic limit of the material.

As before, the general reasoning of Rankine's formula is regarded as correct and also that of Euler, the former being, however, for stability and the latter for failure. Let $\frac{W}{A}$ be denoted by y and $\frac{l}{r}$ by x; then these formulas are

$$y = \frac{S}{1 + q x^2} \text{ and } y = \frac{m\pi^2 E}{x^2}$$

in which q is the constant whose value is to be determined. Next, S being any unit-stress less than the elastic limit, let f be a factor of safety based on that limit, so that $f = S_e \div S$ where $S_e$ is the unit-stress at the elastic limit. Now the first value of y relates to stable equilibrium because S is less than the elastic limit, while the second is for unstable equilibrium or failure by bending. To render the second applicable also to stability, let its second member be divided by f, giving

$$y = \frac{S}{1 + q x^2} \text{ and } y = \frac{m\pi^2 E}{f x^2}$$

as the two equations to be used. To combine these into one equation the curves represented by them must be tangent to each other. For the point of tangency the two ordinates are equal and also the two derivatives of y with respect to x. Stating these two equations and solving, there is found

$$q = \frac{f S}{m\pi^2 E} = \frac{S_e}{m\pi^2 E}$$

and hence there results,

$$\frac{W}{A} = \frac{S}{1 + \frac{S_e}{m\pi^2 E}\frac{l^2}{r^2}}. \qquad (20)$$

which is a rational column formula that entirely avoids the defect contained in (19).

For a very short column, where l = 0, formula (20) reduces to

$$\frac{W}{A} = S$$

and for a very long one, where l is so great that the term unity in the denominator may be neglected, it becomes,

$$\frac{W}{A} = \frac{S}{S_e}\frac{m\pi^2 E r^2}{l^2}$$

and thus the same degree of security obtains for a long as for a short column. If S becomes equal to $S_e$, then the last equation reduces to Euler's formula and failure by lateral bending occurs. Thus, according to this investigation, Euler's formula gives the load P, which causes the failure of a long column when the unit-stress of compression on the concave side reaches the elastic limit.

Formula (20) is not to be regarded as valid when the unit stress S exceeds the elastic limit $S_e$, but it appears to be the formula which represents the laws of stress in an actual stable column with a greater degree of rationality than any other formula. It is not to be justified or condemned because it does or does not well represent the relation between $\frac{W}{A}$ and $\frac{l}{r}$ for cases of rupture; in this respect it should stand on the same footing as the well-known formula for beams, whose validity rests only on the correctness of the fundamental assumptions and mechanical principles employed in its deductions.

The form of the rational formula (20) is exactly that of the formula of Rankine, and it may be written,

$$\frac{W}{A} = \frac{S}{1 + q\frac{l^2}{r^2}}$$

in which q has heretofore generally been derived from the results of tests of columns to destruction. The following, for instance, are mean values of q thus derived, as stated in the writer's "Mechanics of Materials":

| | Both ends fixed. | Fixed and round. | Both ends round. |
|---|---|---|---|
| Timber | $\frac{1}{3{,}000}$ | $\frac{1}{3{,}000}$ | $\frac{1.78}{3{,}000}$ | $\frac{4}{3{,}000}$ |
| Cast Iron | $\frac{1}{5{,}000}$ | $\frac{1}{5{,}000}$ | $\frac{1.78}{5{,}000}$ | $\frac{4}{5{,}000}$ |
| Wrought Iron | $\frac{1}{36{,}000}$ | $\frac{1}{36{,}000}$ | $\frac{1.78}{36{,}000}$ | $\frac{4}{36{,}000}$ |
| Steel | $\frac{1}{25{,}000}$ | $\frac{1}{25{,}000}$ | $\frac{1.78}{25{,}000}$ | $\frac{4}{25{,}000}$ |

It will be interesting to compare these with the mean theoretic values of q, as computed from

$$q = \frac{S_e}{m\pi^2 E}$$

taking m = 4, 2½, and 1, for the three end conditions respectively, and using $\pi^2$ as 10. For timber the mean value of the elastic limit $S_e$ is 3,000 and that of E is 1,500,000 pounds per square inch; for cast iron in compression $S_e = 20{,}000$ and $E = 15{,}000{,}000$; for wrought iron $S_e = 25{,}000$ and $E = 25{,}000{,}000$; for medium structural steel $S_e = 33{,}000$ and $E = 30{,}000{,}000$. Using these constants the mean theoretic values of q are as follows:

| | Both ends fixed. | Fixed and round. | Both ends round. |
|---|---|---|---|
| Timber | $\frac{1}{20{,}000}$ | $\frac{1}{20{,}000}$ | $\frac{1.78}{20{,}000}$ | $\frac{4}{20{,}000}$ |
| Cast Iron | $\frac{1}{30{,}000}$ | $\frac{1}{30{,}000}$ | $\frac{1.78}{30{,}000}$ | $\frac{4}{30{,}000}$ |
| Wrought Iron | $\frac{1}{40{,}000}$ | $\frac{1}{40{,}000}$ | $\frac{1.78}{40{,}000}$ | $\frac{4}{40{,}000}$ |
| Steel | $\frac{1}{36{,}000}$ | $\frac{1}{36{,}000}$ | $\frac{1.78}{36{,}000}$ | $\frac{4}{36{,}000}$ |

From these two tables of empirical and rational values of q it is seen that Rankine's formula with the empirical constants gives bearing loads for timber and cast iron somewhat smaller than when the rational constants are used, while for wrought iron and steel they are but slightly smaller. The bearing loads deduced from the Crehore-Grashof formula (19) are, however, materially greater than given by the use of either set of the above values of q.

To sum up, the present state of the column question seems to lead to the following conclusions. For the ideal column there are but two formulas; if it remains straight

$$\frac{W}{A} = S$$

is the equation; if it bends laterally and remains in equilibrium.

$$\frac{W}{A} = \frac{m\pi^2 E r^2}{l^2}$$

is the equation applicable to it, and the failure occurs with the slightest increase in W. The actual column, however, must remain in stable equilibrium even when deflected laterally, and the rational formula applicable is

$$\frac{W}{A} = \frac{S}{1 + \frac{S_e}{m\pi^2 E}\frac{l^2}{r^2}} \qquad (20)$$

provided that the greatest compressive unit-stress S on the concave side of the column is less than the elastic limit $S_e$. If S equals $S_e$, then failure begins to occur and no rational formula can represent the ensuing phenomena, because the relation between stress and deformation when the elastic limit is surpassed is not yet understood so as to be rationally formulated.

Although (20) is of the same form as Rankine's formula it appears to deserve a special name, since all the current expressions of Rankine's formula contain q as an empirical constant only. I propose for it the name "Ritter's formula" since it seems to be first deduced by Ritter in his "Dach und Bruecken Constructionen" of 1873. A closely similar formula, in which, however, $S_e$ is regarded as a quantity to be found by experiments on columns, is given by Laissle and Schuebler in their Bau der Brueckentraeger of 1876. No doubt it will be found to have been deduced by other writers also. Ritter's very clear deduction, and the fact that he inserts values of $S_e$ and E so as to give working formulas, demands the recognition of his name as the author of this rational formula.

In conclusion a word of protest should be uttered against the process still going on, of establishing column formulas to fit the results of tests of columns to destruction. A straight line may be drawn tangent to Euler's curve, as was done by T. H. Johnson in 1886, and a good empirical formula be established. A parabola may be drawn tangent to Euler's curve, as was done by Prof. J. B. Johnson in 1892, and another good empirical formula be derived. Such formulas possess no rationality because they are not deduced from the laws connecting stress and deformation; they may be valid for the results of rupture, but how far valid they are for columns not stressed above the elastic limit no one can form a correct judgment. Let it be hoped that no one will accept or reject Ritter's rational formula because it agrees or fails to agree with tests carried to the point of rupture. Let it rather be judged, like the formula for beams, by principles and phenomena occurring within the elastic limit, and if not found satisfactory from every theoretical point of view let it be modified so as to produce a rational column formula that will be universally accepted.

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Discussion by Prof. A. J. Du Bois.

I have read with interest the paper by Mr. Prichard. His mathematical work in the appendix seems to me entirely correct, in view of the imposed ideal conditions, and his final result, which was communicated to me some time ago, appeared to me then, as now, the most important on this topic since the derivation of "Euler's formula."

I have accordingly, with Mr. Prichard's kind permission, already inserted it in the last (10th) edition of my "Stresses in Framed Structures," under the title of "Prichard's Formula." Since then I have learned that this formula has already been given by both Grashof and Winkler. Mr. Prichard has, therefore, rediscovered it.

The well-known "Euler's formula" is:

$$\frac{P}{A} = \frac{n^2 E r^2}{l^2} \qquad (E)$$

where n has the values $\frac{1}{2}\pi$, $\pi$, $\frac{3}{2}\pi$, $2\pi$, for one end fixed and one free, both ends hinged, one end fixed and one hinged, and both ends fixed, respectively.

Mr. Prichard has established in place of this:

$$\frac{P}{A} = \frac{n^2 E r^2}{l l_1},$$

where $l_1$ is the length of the shortened axis, so that $l - l_1$ is the shortening of the axis due to direct compression.

Since from the theory of flexure, we can write for very small deflection,

$$l - l_1 = \frac{P l}{A E} \qquad (I)$$

we can eliminate $l_1$ and thus obtain the Prichard formula:

$$\frac{P}{A}\left(1 - \frac{P}{A E}\right) = \frac{n^2 E r^2}{l^2}. \qquad (P)$$

Since the shortening of the axis $(l - l_1)$ is practically very small compared to the original length l, we see from (I) that we can practically neglect

$$\frac{l - l_1}{l} = \frac{P}{A E}$$

as very small relative to unity, and we thus obtain Euler's formula (E).

Euler's Formula Neglects the Direct Compression.—We see at once that (P) and (E) are identical, if we disregard the shortening $(l - l_1)$ of the axis due to direct compression.

Indeed, if anything is clearly shown by this paper it is just this.

Mr. Prichard writes in the very start of his mathematical discussion

$$E I \frac{d^2y}{dx^2} = -\frac{1}{l_1} P y,$$

while, according to Euler, we should write

$$E I \frac{d^2y}{dx^2} = -P y.$$

The two are identical when $l_1 = l$.

Both, then, integrate twice, but Mr. Prichard takes $x = l_1$ when $y = \triangle$, while Euler takes $x = l$ when $y = \triangle$

Again, both are identical when $l_1 = l$.

Finally, Mr. Prichard obtains

$$\frac{P}{A} = \frac{n^2 E r^2}{l l_1},$$

and Euler obtains

$$\frac{P}{A} = \frac{n^2 E r^2}{l^2}.$$

Again, both are identical if $l_1 = l$.

Thus, not only in the final result, but in every step of the mathematical work from start to finish, this difference exists. Euler disregards the direct compression due to the load, while Prichard does not.

The Prichard formula takes into account this direct compression. This is indeed the only essential difference between the two formulas (E) and (P). Were it not for this, the Prichard formula, as distinct from Euler's, would have no existence.

Why the Prichard formula is independent of $\triangle$.—I must, however, have already struck more than one careful reader as very singular that the Prichard formula gives the load P for equilibrium, independent of the deflection $\triangle$.

It is a common experience that if a deflected column is held in equilibrium by a load P, that load usually depends upon the deflection $\triangle$ and increases with it. How then can we have a value of P independent of the deflection $\triangle$?

The answer to this question has been already given by Rankine, and it shows clearly the significance of both Prichard's and Euler's formulas.

Mr. Prichard has shown that the curve of deflection is given by

$$y = \triangle \sin x \sqrt{\frac{l P}{l_1 E A r^2}}.$$

Suppose now a column hinged at both ends. We should have $y = 0$ when $x = l_1$, and hence if m is any whole number we must have for $x = l_1$

$$\sqrt{\frac{l l_1 P}{E A r^2}} = m \pi \text{ or } P = \frac{m^2 \pi^2 E r^2}{l l_1}.$$

We see at once that $m = 1$ gives the least value of P, which for a small deflection will hold equilibrium. In other words, Prichard's formula (or practically Euler's) gives the value of P just at the limit of stable equilibrium.

For a value of P just less, if the column is slightly bent by any external horizontal force and then released, it will recover its original vertical position, and we have no deflection $\triangle$, for equilibrium. The vertical position is one of stable equilibrium.

For a value of P just greater, the vertical position is one of unstable equilibrium. The vertical ideal column is still in equilibrium, but, if slightly disturbed, it will not recover its original vertical position, but P will fall to a new position where the equilibrium is stable and for which we must have a corresponding deflection $\triangle$.

Limit Length.—Now let $S_e$ denote the elastic limit unit stress. It is evident that as long as P is just below the value given by Prichard's formula (or practically Euler's) and also less than $S_e$, then in such case the column can be slightly deflected without overstraining the inner fibre, and it will recover its original vertical position when released.

But at and within that value of l which gives $\frac{P}{A} = S_e$, we cannot bend the column at all without overstraining the inner fiber. The column when released has a permanent set, and does not quite recover.

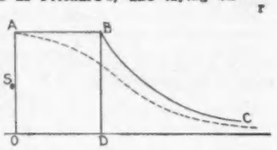
This limit length is then determined by putting $S_e$ in the place of $\frac{P}{A}$ in Prichard's formula. We thus obtain:

$$\frac{l}{r} = \sqrt{\frac{n^2 E}{S_e \left(1 - \frac{S_e}{E}\right)}} \text{ or practically } \frac{l}{r} = \sqrt{\frac{n^2 E}{S_e}}.$$

Inside this limit length we cannot have $\frac{P}{A}$ as given by Prichard's formula (or practically Euler's). Within this limit, for $\frac{P}{A}$ just less than $S_e$, the column can be slightly bent and recover. Such an ideal column fails by direct compression only and not by combined compression and flexure.

Beyond this limit, we can have $\frac{P}{A}$ somewhat greater than given by Prichard's formula (or practically Euler's) and the column can be still slightly bent without overstraining, and will not recover. Such an ideal column fails by combined compression and flexure.

The Ideal Diagram.—Taking, then, Euler's formula as practically the same as Prichard's, and laying off $\frac{1}{r}$ horizontally and $\frac{P}{A}$ vertically, we thus have the ideal diagram precisely as Mr. Prichard gives it.




From the origin O up to

$$O D = \sqrt{\frac{n^2 E}{S_e}}$$

we have a straight line A B. Beyond O D we have Euler's curve B C. O A is equal to $S_e$.

The ordinates to A B C then give for any $\frac{1}{r}$, the limiting value of $\frac{P}{A}$ for stable equilibrium. If $\frac{P}{A}$ for any $\frac{1}{r}$ is less than given by this diagram, and the column is bent slightly by a horizontal force and then released, it will recover its vertical position.

If the value for $\frac{P}{A}$ for any $\frac{1}{r}$ is greater than given by this diagram, and the straight column is slightly disturbed, it will at once bend to a certain $\triangle$, and stay bent. In this case failure is not far off.

If, then, we had to do in practice with the ideal column, the problem would be quite satisfactorily solved. The values of $\frac{P}{A}$ given by the ideal diagram with a proper factor of safety, would give any degree of safety desired.

Practical Formulas.—But we have to do in practice with actual columns which deviate from ideal conditions, each column in its own particular way and no two columns exactly in the same way.

Evidently such a problem is not a question for theoretic treatment. The crippling load for any one actual column can only be found by experiment. Any formula which gives the average crippling load for actual columns must be based upon the average of many experiments.

There is one general conclusion, however, which applies here, which may be stated as follows:

No load can be assumed as ideally centered. But a column under an eccentric load must have a deflection at all lengths above zero. The average failure curve for any actual column, must then pass through A in the preceding Fig., so that $O A = S_e$. All other variations from ideal conditions necessitate the same conclusion. The average curve for actual columns must pass through A.

There is also another conclusion which experiments warrant. That is, that for long columns, the average crippling unit stress $\frac{P}{A}$ approximates to a modified Euler's curve, if we take for n slightly different values from the theoretic ones. These values are the so-called "practical values of n." Thus for both ends hinged, n is found to be approximately $\pi \sqrt{\frac{5}{3}}$ instead of $\pi$, and so on.

Upon these two conclusions all our practical formulas are based.

Thus in the preceding Fig., the curve B C is assumed as the modified Euler's curve, and then a line or curve is passed through A tangent to this curve B C.

It is found for short columns, owing to the great variety of individual deviations from ideal conditions, and the great influence of such deviations, that the results of experiments are so scattered between A and B, some high and some low, that almost any line or curve so drawn gives fairly good average results between A and the point of tangency.

Thus we have the "straight-line formula." This is a straight line through A tangent to B C. Beyond the point of tangency we must use the modified Euler formula. It gives at D, $\frac{W}{A}$ about $0.6\ S_e$.

The "parabola formula" is a parabola horizontal through A and tangent to B C, at a point not so far off as for the straight line. It gives at D, $\frac{W}{A} = 0.75\ S_e$.

Beyond the point of tangency we must use the modified Euler formula.

From the theory of flexure, we have for a column held bent by a load W to a deflection $\triangle$ so that the inner fibre strees is $S_e$.

$$W \triangle = \left(S_e - \frac{W}{A}\right) \frac{I}{v} \text{ or } \frac{W}{A} = \frac{S_e}{1 + \frac{\triangle v}{r^2}} \qquad (2)$$

where r is the least radius of gyration, and v the distance in the direction of this r of the inner fibre from the axis.

The "Crehore-Merriman formula" is of the form of this equation. The term in the denominator is so taken that the curve shall pass horizontally through A and be tangent to B C at infinity. It thus includes the whole range. It gives at D, $\frac{W}{A} = \frac{1}{2} S_e$.

All of these formulas, it will be seen, rest on the same principles and experimental facts. The discussion of the ideal column does not affect the basis of any one of them.

This should be noted, because it might seem from Mr. Prichard's discussion that the Crehore-Merriman formula was more or less discredited. Thus Mr. Prichard concludes that it assumes the inner fibre stress $S_e$ as due entirely to flexure. It makes really no such assumption, because it has no such theoretic basis. A similar formula may be theoretically deduced on such an assumption, but the formula itself rests upon no such theory. It is, like the others, purely empiric. Its form only is taken from theory. It therefore covers the whole range and is in so far theoretically preferable.

This may be clearly seen from the following:

For a column held bent by a load W, to a deflection $\triangle$ so that the inner fibre stress is $S_e$, we have by the theory of flexure, as we have seen, equation (2)

$$\frac{W}{A} = \frac{S_e}{1 + \frac{\triangle v}{r^2}}$$

Now all the practical formulas can be put in this form. It is thus seen that they only differ in the average value of $\triangle$ assumed.

Thus the Crehore-Merriman formula assumes an average value of $\triangle$ at the crippling point, for all values of l, given by

$$\triangle = \frac{S_e\ l^2}{n^2 E v}$$

The parabola formula assumes for values of l within the point of tangency, an average value of $\triangle$ at the crippling point given by

$$\triangle = \frac{S_e\ l^2}{n^2 E v} \cdot \frac{A}{4W}$$

and for l beyond the point of tangency it suddenly changes this average value to practically the same as the Crehore-Merriman formula.

The straight-line formula does the same for l beyond its point of tangency, and for less values of l it assumes for the average of $\triangle$ at the crippling point

$$\triangle = \frac{S_e\ l^2}{n^2 E V} \cdot \frac{2\ r\ n \sqrt{E S_e}}{3\sqrt{3.1}} \cdot \frac{A}{W}$$

It is needless to say that each and all are empiric and must be judged by their agreement with average experimental results. No theoretic discussion can have any value in this respect. Whether the Crehore-Merriman formula should or should not use an average $\triangle$ which varies with $\frac{W}{A}$ is simply a question of experimental evidence. All these formulas are in use. They are all valuable and give good average results.

Which is Preferable?—The parabola formula lies higher than the others. It may then be expected to give, and really does give, the best average values for experiments made with great care as to centering, etc., and for very perfect columns in all other respects. It should be used with this understanding. As such conformity to ideal conditions is not often realized in practice, the values of the parabola formula would seem to run rather high for everyday use. The straight-line gives smaller values and the Crehore-Merriman formula is the most conservative of all.

Moreover, both the straight-line and parabola formulas are tangent to B C at different points. In the light of the ideal column this means that both assume practically ideal conditions for all columns at and beyond a certain length, this length being a different one for each formula.

The Crehore-Merriman formula, tangent only at infinity, avoids such assumptions. In view of this, as well as considering its theoretic form, covering the whole range, and its conservative values in a case where experimental results are still greatly needed, it seems to me, as things now stand, that when used with a proper factor of safety, it is to be preferred to the other two.

Rational Formulas.—The one thing which seems plain to me from this paper of Mr. Prichard, is that for actual columns there can be no one completely "rational" formula. Every column has its own characteristic deviations from ideality and no two are alike. A formula which does not include each special deviation cannot be completely rational. To search for such a formula is to pursue a phantom. The average actual column is all we can deal with, and that, like the "mean man" of the insurance agent, is a matter of experience and statistics, and not of mathematical deduction.

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### Discussion by Prof. J. B. Johnson.

I have read Mr. Prichard's article on "Ideal Columns" with much interest. I think it is perhaps the clearest analysis of a theoretical character I have seen. His equation (14) is the same, and derived in much the same way as equation (1), p. 144, of "Modern Framed Structures," with the term expressing the effect of eccentric loads omitted, and with the use of $\pi^2$ in place of 10. As $\pi^2$ is the theoretically correct quantity, the formula con-

taining it is better than the approximate one, although the error is only about 1% in one term, or say from 1-10 to ¼ of 1% in the resulting value of the stress per unit area, $\frac{W}{A}$. The true theoretical locus of a horizontal line out to the locus of Euler's formula and then down that curve was also pointed out in Art. 13 of the above-named work.

Mr. Prichard shows clearly that the assumption which has to be made to reduce this true formula to the form of the Gordon or Rankine formula is quite inadmissible, as a theoretical deduction, and hence the supposed theoretical values of the co-efficient of $\left(\frac{l}{r}\right)^2$ in the denominator of that formula, as recommended by Crehore, Merriman, and Du Bois, are not admissible. They rest on the assumption, as shown by Mr. Prichard in the derivation of his equation (19), that the total stress on the most compressed fibers comes wholly from bending, whereas, it is only the total stress, minus the $\frac{W}{A}$ stress, which comes from bending. The error involved in this assumption, whereby Eq. (17) is derived from Eq. (13), is just about 100 per cent. of what remains in this subtractive term, —second term of the denominator of Eq. (12)—since for the shorter columns for which Euler's formula is applicable $\frac{W}{A} = S_e - \frac{W}{A}$, or $\frac{W}{A} = ½ S_e$. Hence $S_e - \frac{W}{A}$ as in (13), is one-half of $S_e$ in (17), which is substituted for it. The locus of this formula should become practically tangent to Euler's curve for moderate lengths of columns instead of at $\frac{l}{r} =$ infinity.

Mr. Prichard's modification of Euler's formula in using $l_1^2$ in place of $l^2$ is theoretically correct, if it is true that iron and steel deforms under external forces, inside the elastic limit, by equal increments of the *original* length for equal increments of the load. If $l^2$ is used, we assume that the increments of the deformation are equal parts of the *instantaneous* length, for equal increments of the load, and also that the final length is the same as the original length, in evaluating x in equation (11a). It is, I believe, quite impossible now to affirm which of the former assumptions is true, or whether or not either of them is strictly true. The difference between them is smaller than our present knowledge of the subject can determine, and hence I think no one could say whether the one or the other of these forms is more nearly correct theoretically. Practically, of course, they are the same, since for all working values they do not differ by more than from one-twentieth to one-fiftieth of 1%. As to the evaluating of x in equation (11a), there is no question but it should be taken as $l_1$, as Mr. Prichard has done, if one wishes to be strictly accurate, but it should be noted that $l_1$ is now the shortened (vertical) length from *both* compression and from bending, and hence the assumption made in Eq. (6) is not correct, since there the shortening is assumed to be wholly due to compression. I have here plotted (Fig. 10) the tests of pivoted wrought-iron columns of large or of structural size, made by Prof. Tetmajer, and reported in the fourth volume of his "Communications." These being the most carefully conducted experiments on full-size columns with pivoted ends ever made, they should fix the practical value of any proposed formula. It will be seen at a glance that neither the purely theoretical formula (16), the locus of which is a horizontal line through the elastic limit to an intersection with Euler's curve and then down that curve, nor formula (19), here credited to Crehore, Merriman, and Du Bois, the locus of which is the lower curve, approaches anywhere near the ultimate strength of actual columns, although both are drawn for the particular values of $S_e$ and E, found by Tetmajer for his materials. Evidently the curve in Fig. 2 (Eng. News, May 6, p. 278), represented as the locus of Eq. (19), has been put in by guess and is not a locus of that equation at all. It will also be seen from Fig. 10 (1) that for great lengths, such as are never used in practice, Euler's formula, without any empirical constant, fits the observations exactly. This is because the ends were pivoted on knife edges so that very long columns should be expected to resist only by bending, as assumed in the derivation of this formula. (2) That the parabolic formula, first proposed by the writer in his chapter on columns in "Modern Framed Structures," does fit the observed results as closely as any curve can be made to do.

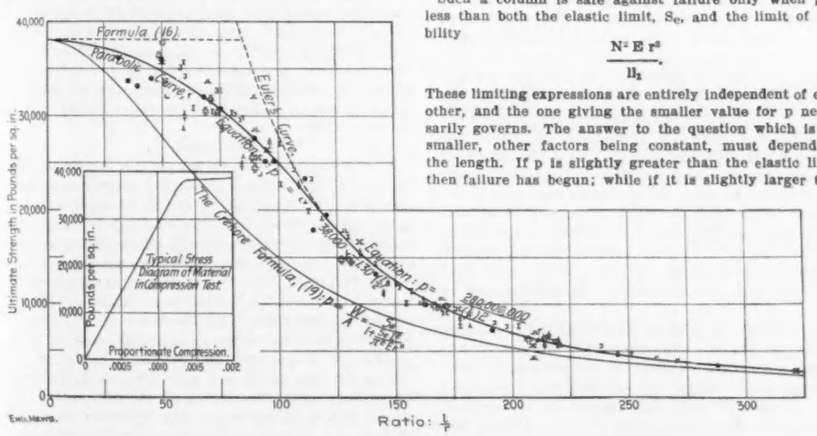


FIG. 10.

If it be objected that these observations do not correspond to actual conditions, as for pin ends instead of pivoted ends, it must be admitted that this is true and that for pin ends the results would be higher than here shown. But this simply throws the Crehore formula so much farther from the facts, for it is already some 40% too low for ordinary lengths.

While Mr. Prichard's discussion, therefore, should clear up this subject in the minds of those who have hitherto failed to understand it, it introduces no new matter of any practical significance, neither do I understand that it was intended to do so.

It does show the exact nature of the fallacy involved in the Crehore formula, which has been regarded by many as one resting on a substantial theoretical basis, and this alone is a valuable service rendered to the profession, and a substantial addition to the literature of the subject. Although this error was not specifically pointed out by the writer, it appears in his equation (1) p. 144 of "Modern Framed Structures." If the term expressing eccentric loading be omitted, the formula is the same as the Crehore formula, except f — p is used where f alone is used by Crehore. This is the same omission as that pointed out by Mr. Prichard in deriving his equation (19).

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Discussion by Henry S. Prichard.

The paper and its discussions are in entire accord regarding the vital facts that, while an originally straight centrally loaded homogeneous column remains straight, the stress per unit of area, s, equals the load per unit of area, p, and the greatest load compatible with stable equilibrium is

$$P = \frac{\pi^2 E I}{l l_1} \qquad (5)$$

Such a column is safe against failure only when p is less than both the elastic limit, $S_e$, and the limit of stability

$$\frac{N^2 E r^2}{l l_1}.$$

These limiting expressions are entirely independent of each other, and the one giving the smaller value for p necessarily governs. The answer to the question which is the smaller, other factors being constant, must depend on the length. If p is slightly greater than the elastic limit, then failure has begun; while if it is slightly larger than the limit of stability, the least jar will cause complete collapse.

About the question whether when the limit of stability is exceeded in the slightest degree, the column will bend to failure, or instead assume a new position of equilibrium, there is some disagreement, but it is of no direct practical importance, as will be seen by comparing Prof. Merriman's modified Euler's formula with the equation:

$$\frac{P}{A} = \frac{\pi^2 E r^2}{l^2} + \frac{P^2}{A^2 E}. \qquad (7)$$

For instance, for the conditions $l = 200$ inches, $r = 1$ inch, $V = 1½$ inches, $E = 29{,}000{,}000$ and $\triangle = \frac{\left(S_e - \frac{P}{A}\right) l^2}{\pi^2 E V}$ = about 2.1 inches for soft steel, Prof. Merriman's modified Euler gives for $\frac{P}{A}$, 6,668 lbs.; equation (7) gives 6,664 lbs., and Euler's formula gives 6,662 lbs. For smaller values of l the difference between Prof. Merriman's modification and equation (7) is still less, but the difference between Euler's formula and equation (7) is greater.

A comparison of these results is interesting because it indicates within what narrow limits such differences as exist in the discussion of the ideal column are confined and the discussion of this subject might well end here were it not that Prof. Merriman attaches considerable importance to the deductions which his modification shows.

It is one of the ordinary assumptions of flexure that the deflection is so small that the abscissa x and its differential, when involved simply as factors, can be used interchangeably with the corresponding distances measured on the axis. In determining the deflections of a beam errors of this kind occur twice, first in obtaining the fundamental equation for curvature and second in substituting some proportion of l for x for deflections at some certain point, as may be seen by reference to any standard work on the subject. In dealing with columns the paper follows this established precedent and the errors resulting therefrom are very small. Prof. Merriman corrects one of these errors only in introducing $l_2$, but the correction is of doubtful value because the errors tend to neutralize each other.

The fundamental equation for curvature of columns, as given in the paper and adopted by Prof. Merriman, is

$$\frac{P y l}{E I l_1} = \frac{I}{\rho} = -\frac{d^2 y}{d x^2}, \qquad (c)$$

but from calculus the last member of the equation should be

$$\frac{d^2 y \, d x}{d z^3} = -\frac{d^2 y}{d x^2} \times \frac{d x^2}{d z^2} \times \frac{d x}{d z},$$

in which z is the length of the curve from origin to point under consideration.

Substituting this correct expression in (c) and transposing, gives

$$P = -\frac{l_1 E I}{l y} \times \frac{d^2 y}{d x^2} \times \frac{d x^2}{d z^2} \times \frac{d x}{d z}. \qquad (c_1)$$

If the usual course of neglecting $\frac{d x^2}{d z^2} \times \frac{d x}{d z}$ is pursued and subsequently $\frac{l_2}{2}$ is correctly substituted for x, Prof. Merriman's modified Euler's formula results, while if $\frac{l_1}{2}$ is incorrectly substituted for x, equation (7) results; but if instead of the usual course $\frac{d x}{d z}$ only is neglected, which is less of an error, and $\frac{l_1}{2}$ is subsequently correctly substituted for z, then equation (7) results. As the factor $\frac{d x}{d z}$ equals unity for an infinitesimal deflection and decreases in value as the deflection increases, and as its neglect leads to the same value for P, no matter what deflection is assumed, it seems plausible to suppose that its consideration would indicate a very slightly decreasing value for P for increasing deflection; but be this as it may, it is evident that a straight homogeneous column, centrally loaded almost to the limit of stability, will require but a very slight addition to the load to insure bending to failure.

That this is not a matter of common experience is because such experience is with columns which from slight bends in the axis, imperfect centering, lack of homogeneity and from transverse forces are subjected to a finite bending moment of greater or less magnitude from the start.

A consideration of this bending moment is necessary to the rational design of columns under actual conditions. Rankine's formula does not consider it; and Rankine did not suppose that it did, for he states on page 238 of his "Civil Engineering:"

"It is to be observed that these formulae, as they stand, are strictly applicable anly to cases in which the line of thrust sensibly coincides with the axis of the strut."

Its claim to construction as a rational formula must rest on the accuracy with which it indicates the behavior of columns under the conditions on which it is based. It was for the purpose of pointing out the error in Rankine's reasoning and of showing that his formula is not, even with the modification advocated by the weighty authorities mentioned in Prof. Merriman's discussion, a theoretically correct deduction from the conditions assumed by him (Rankine), that the formula was discussed in the paper.

The object in writing the paper was neither to bring out new facts or discuss practical design (this latter is reserved for another paper now nearly completed) but simply to aid in establishing the true ideal; but it should be remarked that while it is true, as stated by Prof. Du Bois, that there can be no one rational formula for all deviations from ideal conditions, that nevertheless it is entirely feasible to make reasonable assumptions as to the actual conditions for each case and to design rationally by the particular formula applicable. Prof. Du Bois starts to develop one such formula but, unfortunately, though intentionally, drops out the only quantity which distinguishes the conditions assumed from ideal ones.

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The serious leakage, which has for the time being disabled both of the timber dry-docks in the Brooklyn Navy Yard, calls for some comment. In the first place, it is nonsense to assert, as has been done in the daily press, that the experience in Brooklyn has sorely shaken the faith of the Navy Department officials in the timber type of dock construction and would induce them to favor stone alone for future use. The trouble in Brooklyn is primarily due to the bad character of the soil in which the docks are built. This soil is filled-in ground, originally traversed by lines of old timber cribs filled with loose stone, which are so many conduits for water coming either from the water front of the yard, or possibly from the land side, and extensive quicksands are known to exist in that neighborhood. The weak point in this timber dock construction, on a site of this character, is that the water-tight qualities of the structure are practically solely dependent upon the tightness with which lines of sheet piling can be driven around the dock location. The clay filling back of the altars, or inclined sides, can not be depended upon; for its homogeneous nature is interfered with by the piles supporting the altar-braces; and the present case proves that water, when it once passes the barrier of sheet-piling, will penetrate this clay and find its way into the dock. No engineer need be told of the difficulty of obtaining tight work with sheet-piling driven among timbers, loose stone and the miscellaneous material usually employed in filling up an old dock. But the remedy in this case is not so easy to suggest; especially as until the present board of engineers has completed its investigation the direct source and primary cause of the leakage can be little more than guessed at.

The present experience, however, would seem to call for greater caution in the employment of the all-timber type of construction in known bad ground. A dry-dock, whatever else it is, should be water-tight when use requires this condition; and it does seem that the integrity of a single line of 5-in. or 8-in. sheet-piling is too uncertain a quantity upon which to base so large an expenditure and the permanent efficiency of the structure. In England concrete has been successfully used under like conditions of ground; and though this concrete is liable to settlement cracks, such as occurred, for example, at the Alexandra dock, at Belfast, these cracks can be permanently closed and the work rendered secure against all contingencies of leakage or destructive pressures. The cost is greater than that of a timber dock; but in the Brooklyn dock the floor is already concrete, and it successfully withstands the lifting pressure put upon it by the presence of water under a 30-ft. head. The Newport graving dock, in England, was built upon made ground, and its walls are partly supported upon piles and partly upon the natural earth, a trying structural condition. It is built wholly of concrete, excepting only the hollow quoins and sills, which are masonry, and has given full satisfaction both in use and in its first cost. In fact, it cost only $125,000, and it is 350 ft. long by 50 ft. wide on the floor. This compares very favorably with $548,700 for the first Brooklyn timber dry-dock, which was 500 ft. long and about 50 ft. wide on the floor. The Newport dock, however, was closed by gates instead of a caisson. The more extended use of concrete in our timber dry-docks is already advocated by the engineers of the Bureau of Yards and Docks, in the walls above the water line, in the gate abutments and in the approaches. Even the material increase in cost in making the inclined sides wholly of concrete would seem to be warranted where the conditions of site are such as to cause a doubt as to the permanent tightness and efficiency of the all-timber construction. The initial cost of a government graving dock is hardly of as much importance to the public as the liability of having a dock disabled and out of service at a time when it is badly needed. The Navy Department is even now having an experience of that kind, in finding itself with several battleships that badly need docking, and without a dock on the Atlantic coast in a condition to receive them. It is sincerely to be hoped that the damage to the Brooklyn docks can somehow be speedily remedied; but the lesson to be learned there should be utilized in future construction on the same, or similar sites.

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New Orleans is the only large city in the United States that has entrusted the providing of a sewerage system to a private company, and after five years of waiting on the company the city is still without sewers. In 1892 the city granted a franchise for sewers which was very liberal to the grantee but reserved nothing for the city except free service to city buildings and charitable institutions not self-supporting. The city agreed to make every one along the line of the sewers connect with the system, at the same time establishing in the franchise the maximum rates to be paid for the service. The rate for dwellings was based on the number of rooms. Houses having from 5 to 8 rooms were to pay $1.20 a month, or if paid for a full year, "in advance," the charge was to be $9.

The franchise stipulated that the main part of the city should be provided with sewers within five years, at least one-fifth of the area to be covered each year. After this section was completed the remainder of the city was to be covered in another five years, the company to extend the sewers in this second section:

> wherever the inhabited houses are not more than 50 ft. apart, but it shall not be compelled to pass an interval of more than 50 ft. on either side of the street to drain a closely built area beyond.

While the company was not to be compelled to pass a 50-ft. interval it could build its sewers at any time and any where it wished.

The company has done but little work, and is now in the hands of a receiver, with a suit brought by the city for the annulment of its franchise hanging over it. Recently the New Orleans Sewer Co. was organized to succeed the old company, known as the New Orleans Sewerage Co. The new company is now asking the city to approve the transfer of the franchise from the old company to it and to withdraw its suit for the annulment of the franchise. In return the new company offers the city two out of nine directors and

> 15 per centum in the net profits of the company, meaning thereby the surplus of such profits, after first deducting the necessary costs of maintenance and administration, and interest at the rate of 6 per cent. per annum on the money already expended, or to be actually expended in the construction of the work.

The city of New Orleans should not be deluded by any such offers as these. If after its five years of experience with a sewerage company and its two or three years of experience with a garbage disposal company, whose contract it is also trying to annul, it still wishes sewers under private control, that is one thing; but it ought to know that to expect any good from such an arrangement as the above can only prove a disappointment. The city backed by ownership of a good block of stock that has a part in the directory of the water company, that does not relieve it from the muddiness of the Mississippi River water, which is so unpopular that not long ago over half of the service connections made were not in use, while on April 1, 1895, there were but 4,800 taps in use for a population which in 1890 was 242,000. As to a share of the net profits, who ever heard of a company under such a contract that did not so doctor its accounts that its payments to the city were practically nothing? The only true basis for dividing the profits between a city and franchise company, as most careful and disinterested students of the subject now agree, is the gross and not the net receipts.

But is it a share of the profits that New Orleans wants? In practically all the other cities, towns, and even villages and hamlets of the United States and Canada, sewerage systems are owned by the municipality and an annual charge for connections is no more thought of than a toll for driving or walking through the city's streets. True, the citizens pay the first cost of constructing the sewers, either in taxes or assessments, but everything is done to encourage the use of the sewer. Compulsory connections are sometimes enforced in the interests of health, but these are often resisted where no annual charges are to follow and where fees for entrance permits are turned into the city treasury. The proposition to compel people to connect with a sewer and then pay a private company yearly charges would raise a riot in other parts of the country, even though the charges were not unreasonable. Sewerage systems throughout the civilized world have always been regarded as the one class of public works which should never be entrusted to private companies. We have taken pains for some time past to note all instances of private ownership of sewerage systems in the United States and we do not know of 20 sewerage franchises in the whole country, and with the sole exception of New Orleans those are all held in cities or towns which had less than 15,000 inhabitants in 1890.

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At the coming convention of the American Society of Civil Engineers, several proposed amendments to the Constitution are to be discussed and acted upon. These amendments chiefly affect the status of the Past Presidents of the Society, who, under the existing constitution, are active members of the Board of Direction and are Trustees of the Society, as provided by the laws under which the Society is organized. As the term of office of the President is now limited to one year, and he is ineligible for re-election, the practical result of this ruling is that there are now twelve living Past Presidents who are included in the active list of the Board of Direction and Trustees and their presence is necessary in constituting a legal quorum. The law requires a two-thirds attendance of the Trustees of the Society for the transaction of business, and as these Past Presidents are scattered all over the country, it can readily be seen that the Board as at present constituted is an unwieldy body and the business of the Society is being conducted under difficulties, especially as the construction of the new society building now requires frequent meetings of the Trustees. To remedy what is rapidly becoming a serious source of trouble, and one that will increase as each year adds another member to the governing body, eight of the Past Presidents now propose to amend Section 1, Article V., of the Constitution so that it shall read as follows:

**Article V.—Officers.**

**"1.—The officers of the Society shall be: A President, four Vice-Presidents, eighteen Directors, a Secretary, and a Treasurer, who shall constitute the Board of Direction, in which the government of the Society shall be vested, and who shall be the Trustees as provided for by the laws under which the Society is organized. All living Past-Presidents, who continue to be members, shall be entitled to be present at all meetings of the Board of Direction, and to discuss all questions coming before the Board and aid the Board by their advice and counsel; but said Past-Presidents shall not have a right to vote, nor shall their presence be requisite in order to constitute a quorum."**

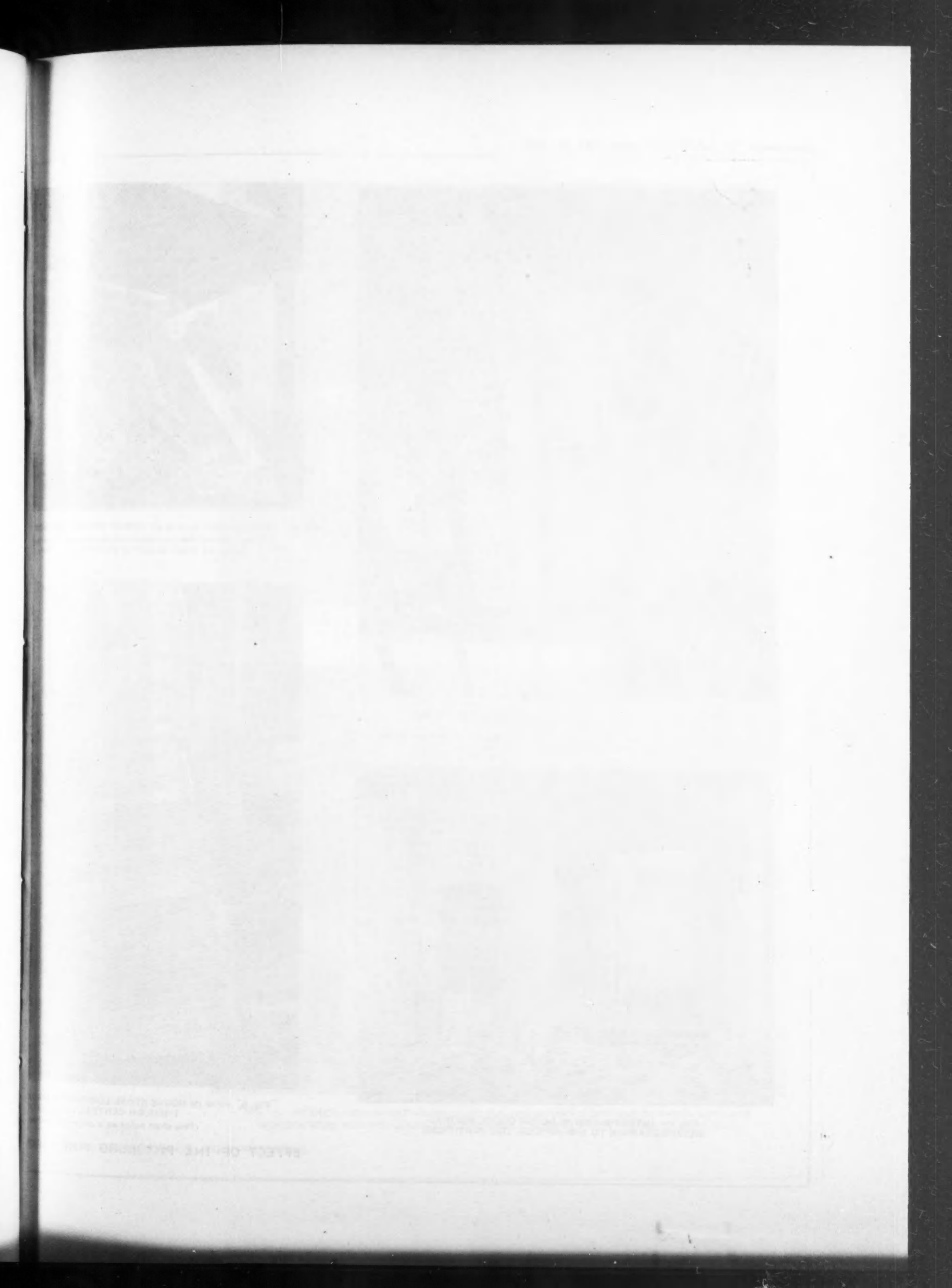


FIG. 10. VIEW IN HORNE OFFICE BUILDING LOOKING UPWARD FROM FIRST FLOOR TOWARD SKYLIGHT.

(This view to the roof was made possible by the dropping out of the floor arches, there being no light shaft as in the Horne store.)

FIG. 11. INTERIOR VIEW IN HORNE OFFICE BUILDING SHOWING DAMAGE TO 4-IN POROUS TILE PARTITIONS.

FIG. 6. VIEW ON FIRST FLOOR OF HORNE STORE LOOKING TOWARD

(This view shows the southeast interior where the damage was

left is the wreck caused by the fall of the water

FIG. 8. VIEW IN HORNE STORE LOOKING UPWARD FRO THROUGH CENTRAL LIGHT SHAFT.

(This shaft acted as a chimney for the flame

EFFECT OF THE PITTSBURG FIRE UPO

OOKING TOWARD PENN AVE. FRONT.
he dam was greatest; to the
e water from the roof.)

FIG. 7. VIEW ON THIRD FLOOR OF HORNE STORE LOOKING TOWARD PENN AVE. FRONT.
(This view shows the southwest interior where the damage was least.)

PWARD FROM FIRST FLOOR
HT SHAFT.
for the ames.)

FIG. 13. INTERIOR VIEW IN METHODIST BOOK BUILDING SHOWING DAMAGES TO METAL LATH AND WOODEN STUD PARTITIONS AND THE UNINJURED CONCRETE FLOOR ARCHES OF 16-FT. SPAN.

UPON DIFFERENT KINDS OF FIREPROOFING.

Eleven members of the Society, including two Past Presidents, suggest another amendment of Article V., in two separate propositions, differing only in a few immaterial words, as follows:

"1.—The officers of the Society shall be a President, four Vice-Presidents, eighteen Directors, a Treasurer, and a Secretary. The President, Vice-Presidents, Directors and Treasurer shall be the Trustees as provided by the laws under which the Society is organized. The President, Vice-Presidents, Directors, Treasurer and all living Past-Presidents of the Society who continue to be Members, shall constitute the Board of Direction in which the government of the Society shall be vested."

These two amendments differ in several essentials. The first proposes to reduce the number of the Board of Directors and the Trustees by eliminating the Past Presidents as a voting body necessary to constitute a legal quorum. But their advice and counsel is sought and the Past Presidents are invited to enter into the discussion of all matters coming before the Board. The second amendment simply provides that the Past Presidents shall not act as Trustees, but shall continue in full power, as members of the Board of Direction, in all matters pertaining to the government of the Society. The decided objection to the second amendment is that it proposes to substitute for one body of men, already found to be unwieldy in the transaction of business, two governing bodies which are liable to create still further trouble of the kind now complained of. Under the present limitation for the term of President, each year will bring relatively younger men into that office, and it may well occur, in a comparatively short time, that the Past Presidents will constitute a majority of the Board of Direction and constitute a permanent governing body. There may be nothing especially objectionable to this, other than the difficulty of getting together, for business purposes, so large a board; but such a condition would be contrary to the spirit of the Constitution of the Society, which calls for its management by a representative body annually elected by the members.

The practice of the Institution of Civil Engineers in this respect is to permit the Council, which is elected annually, to select any number of Past Presidents, "not exceeding four," to act as members of the Council for the same year. The Council is so constituted that it shall not have less than 23 members, nor more than 31, exclusive of the Past Presidents appointed by the Council, as each Council may decide for the ensuing year; and in this body, so limited, are vested the direction and management of all the affairs of the Institution, under the control of the charter, by-laws, regulations and resolutions of special general meetings of the corporate members. There is no objection to permitting a limited number of the Past Presidents of the American Society to act with the Board in a similar manner; but to divide the responsibilities of government between two bodies of men, one of them only limited in number by the annual death-rate, is the reverse of a businesslike and compact organization and could hardly be beneficial to the interests of the Society.

While the two amendments quoted differ in the proposed status of the Secretary, one retaining him upon and the other deposing him from the Board of Direction, the disposal of this question seems to be of secondary importance. The Secretary is now appointed by and holds office at the will of the Board of Direction, and it is not in accordance with usual practice that an officer should have a vote in the body which nominates and elects him to office. In the Institution of Civil Engineers, both the Treasurer and Secretary are appointed annually by the Council, but neither have a vote in that body and act only as agents of the Council.

## FIREPROOF CONSTRUCTION IN THE PITTSBURG FIRE.

The destruction of several fireproof buildings in the recent fire at Pittsburg, Pa., which is described quite fully elsewhere in this issue, may confidently be expected to bring up for discussion again the old question of the efficiency of modern fireproofing systems. Probably, indeed, the reason the disaster has not already received more attention in this regard may be attributed to the fact that outside of a very limited circle, the real story of its character and extent is not known. Although such a discussion means much rethreshing of old straw, it is very desirable that it should be had, for there is yet a great deal to be learned by architects, builders and engineers, not only about fireproofing systems, but also concerning the broader and more neglected subject of protective construction against fires. It is because of these facts partly that Engineering News has been at some trouble to collect the evidence regarding the Pittsburg fire and its effects, and to present it in such a form as will enable its readers to determine its significance and bearing upon the important question of fireproof construction.

The story as told may be summed up in a few lines as follows: A fire starts in an old type of brick and wood, slow combustion building filled with highly inflammable material, and before its progress can be checked it sweeps over an area of nearly two city squares, destroying property to the amount of $3,000,000. Within this area, besides the first-mentioned building, there were three modern fireproofed, steel skeleton buildings, and a half-dozen small shops and dwellings of ordinary brick and wood construction. When the flames had completed their work there remained of two of the fireproof structures only the outer walls and shattered floor arches held together by the steel frame, the third fireproof building had five of its eight floors swept nearly clean of their contents and their dividing walls and partitions injured beyond repair, and the brick and wood shops and dwellings were simply heaps of masonry.

To a hasty observer the evidence thus briefly stated will doubtless seem a serious indictment of the much-argued advantages of fireproof building construction, and a very considerable number of people may be expected to take just this hasty view. To the architect and engineer, however, who studies the evidence more carefully in its details, we believe that it should suggest a far different conclusion, and as the duty will fall upon these more expert observers to set aright the views of their clients it will be time well spent to analyze somewhat carefully the data presented.

Considering the evidence in its general aspects first, several facts of broad significance attract attention. The rapid progress and the intensity of the fire are especially evident. The reasons for this are not far to seek, being evidently the presence of vast quantities of inflammable material upon which the flames could feed and the open exposure of these combustibles to easy ignition, especially in the Horne store and office buildings. Indeed, there seems to be some irony in calling buildings fireproof which oppose hardly anything to a fire from across the street more sturdy than plate glass. In the Horne store, too, after the flames had gained access through the open front, there were no dividing partitions to delay their progress, and even the different floors were open to each other by a large light shaft and several smaller vertical openings. Indeed the conditions in this structure could hardly have been made more favorable for the rapid spread of the flames. Given such conditions it is obviously only a question of sufficient fuel to feed it for a fire to destroy any fireproofing.

Turning now to the adjacent office building it will be noticed at once that the provisions against the spread of fire were somewhat better than in the store building. The front exposed to the fire was fully as weak it is true, but there were dividing partitions both transversely and longitudinally above the first floor, although not very strong ones, and fewer and smaller vertical openings. It is reasonable to assume that these facts account in some measure for the better condition of the fireproofing, although doubtless the smaller stock of combustibles and possibly the use of porous tile and the end construction of the floor arches also contributed to the more favorable result. Another fact which is of interest in connection with the fire in this building is that the flames appear to have passed along the first floor which was open to the rear, and then to have ascended the elevator shaft and the stairway to the rear rooms of the floors above. The building was thus attacked by the flames nearly simultaneously in the front and the rear.

Before proceeding further it is well to consider for a moment what the lesson is that is taught by the general facts previously outlined. It seems to us to be simply that the protection of buildings against fire does not stop with the rearing of a steel skeleton and clothing it with an integument of incombustible and non-conducting material; but includes impervious outer walls, with a minimum of window and door areas, and these protected by fireproof shutters, frequent dividing walls, and inclosed elevator shafts, stairways and similar vertical openings. A provision for fighting fire is also an important consideration, although in a fire like the one under consideration, occurring in the night and spreading so rapidly as it did, there is very little opportunity to use the ordinary building hose and hand grenades.

A second fact of prime significance in connection with the fire as a whole is that the three fireproof buildings, namely the two Horne buildings and the Methodist Book Building, established the boundaries to the progress of the flame in two directions. In this respect, at least, they proved of inestimable value, since if the fire had once passed them it would have had a fertile field of small buildings filled with lumber and combustible merchandise to feed upon. The question may with reason be asked here: why, if these buildings furnished so little opposition to the flames at their fronts, did they so efficiently restrict their passage at the rear? The answer to this question is evidently found in the fact that in the Methodist Book Building and the Horne office building the rear walls were of brick and without windows, while in the Horne store building the rear wall had a small window area as compared with the front, and all windows were closed with fireproof shutters. It seems the irony of fate almost that these very shutters which had been built to protect the store building from its apparently more dangerous neighbor should have served at their first trial the opposite purpose of saving that neighbor from destruction.

But not to stray too far from the main thought, let us see just what the efficiency of these protections proved to be. As already noted, the fire did not pass to the building adjacent to the windows covered by them. Further than this, investigation showed that while the window framing and the merchandise adjacent to it were in ashes, none of the shutters had been burnt through. Only one shutter was seen which seemed to have been burst open by the fire or the attack of the firemen upon it, although all were more or less warped. The heat to which these shutters were subjected, however, must have been very intense, for only a few feet from them were found masses of half-melted crockery and glassware and the distorted tubing of bicycle frames. These tests were certainly crucial ones and that they were so successfully withstood speaks stoutly for the value of fireproof shutters.

Unfortunately this favorable evidence cannot be supplemented by any very reliable records of the action of the shutters on the Cicil Alley side of the Jenkins Building, as this wall fell early in the conflagration and only the evidence of more or less unreliable eye witnesses of the fire is available for consideration. According to one report in a local newspaper these shutters held until heated to a white heat and did not permit the flames to pass, but how much longer they remained effective is nowhere stated. It is a fact, however, that the Methodist Book Building directly opposite these windows was the last of the larger buildings to take fire, but this was doubtless due to a considerable extent to its smaller exposure of window area, so that the existence of shutters on the Jenkins building cannot be positively asserted to have been the cause of its later ignition. The evidence, we think, may be pretty justly summarized by stating that nothing can be said unfavorable to the efficiency of these shutters while a good deal can be said in their favor.

Passing to a consideration of the damage done by the fire to the more purely structural features of the several buildings, one is impressed at once with the splendid showing made by the steel frames. Not a single steel member can be said to have been torn from its position in the structure by the heat of the fire or the destruction of its protecting fireproofing. In the Home store buildings at least 50 per cent. of the columns and floor beams were found partly or wholly uncovered, but only slight bends were found in two or three columns. The thing responsible for the damage to most of the injured steel work in this building was the

fall of the heavy steel water tank from the roof, and this accident seems to have been due to the reprehensible construction of the tank supports on the roof, which were of wood that burned away and allowed the tank to crush onto the light roof framing. The steel work in the Horne office building showed no injury except for occasional bent floor stringers, and that in the Methodist Book Building did not seem to be injured at all.

These facts appear to us to be very significant. Much has been said at one time and another regarding the horrible distortion which might be expected should one of our modern steel skeleton structures be subjected to an extensive fire, and it is very gratifying to have these assurances refuted by practical test if only to the extent afforded by the Pittsburg fire. It will probably be contended by no one that expansion and contraction did not occur, perhaps to a greater extent than the uncovered framework indicates, but it can be asserted that the danger of wholesale destruction from this cause does not seem to be very great. Despite all this, however, it must be borne in mind that these Pittsburg structures had large lateral dimensions and no very great height in comparison, and also that a very high character of steel construction was used. A similar fire in some of our chimney-like metropolitan office buildings might mean a far different result.

When we turn to the action of the fireproofing protecting the steel we find the results of the fire somewhat more difficult to analyze. In each of the three buildings a different kind of fireproofing material was used and in each the intensity and progress of the fire itself varied. It is hadly fair, therefore, to assume from the appearance of the ruins alone any special excellence for any one kind of fireproofing as compared with the other. There is no very good reason to doubt, however, that the heat was most intense in the Horne store building, less severe in the Horne office building, and least trying of all in the Methodist Book Building. The damage to the fireproofing in these three buildings ranks in severity about in the same order. Between the Horne store and office buildings the difference in the intensity of the fire was the least, undoubtedly, and it may be reasonably assumed that the better action of the fireproofing in the office building was due to some extent to the use of the porous tile and the end construction of the arches. This rather upholds the very general opinion that the porous tile and the end construction is superior to hard tile and side construction.

A particular feature to be remarked is that no particular part of the fireproofing seemed to resist the fire better than another; the column tile, the floor arches, and the beam flange covering seeming to have been destroyed about equally. In the office building where partitions were used, their destruction was pretty serious, as might have been expected. No very great stability against fire and streams of water can be expected from partitions of 4-in. tile, and the wonder is that they stood as well as they did. In respect to their efficiency, however, there does not seem to be much choice between partitions of 4-in. tile and metal lath and wooden stud partitions used in the Methodist Book Building, and the builder who pins his faith to either to resist a severe attack of fire and water is likely to be disappointed.

The behavior of the 16-ft. span concrete floor arches in the Methodist Book Building must, we believe, be conceded by every fair-minded man to have been most excellent and to justify the faith which many architects and engineers have shown in concrete floor constructions. It is true that the heat to which they were exposed was not as great as that in the buildings with the tile construction; but it is also true that many of these concrete arches were in the midst of a very severe fire for a considerable time, and came through it, with hardly an exception, absolutely unharmed. We believe that the Pittsburg fire adds convincing evidence to that already accumulated in engineering literature that concrete is entitled to rank as a material of the highest value in fireproof construction.

In what has preceded will be found some of the suggestions which the fire at Pittsburg seems to offer to architects and engineers, and doubtless others will be found in studying the story of the disaster given elsewhere in this issue. To such experts we may confidently entrust the evidence given for a fair consideration, but the general public will hardly lay so much stress on these finer points and will want an unqualified answer to the question, whether the Pittsburg fire did or did not prove the uselessness of fireproof construction? It may be answered at once that it proved the value of such construction, if for no other reason than that these fireproof buildings prevented the spread of fire beyond them. It is true that the business man may see little inducement to fireproof construction if it means loss on the fireproof building and safety beyond it, but he can also see that if the fronts of these burned buildings had been as well protected as their rears the fire would have had serious difficulty in ever entering them. Just here is the thing that the average builder has been prone to overlook. He will go to great expense to make his building incombustible, and then, for reasons of economy, or to display his goods, or to gain some other end which he desires, he will stop short of making it reasonably inaccessible to fire. The three fireproof buildings at Pittsburg were destroyed by an exposure fire, and they could have been hardly more open to the access of such a fire if their whole fronts had been lacking.

We are not overlooking the fact that buildings must be suitable for occupation and business and, therefore, must have doors, and windows and stairways, but these can all be had and the openings still be protected in such a manner as not to afford free access to flames and heat. For example, there was no structural reason why the windows of the Horne store and office building at Pittsburg should not have had rolling steel shutters, and if they had, is there much question but that the firemen from inside these buildings could have saved both from serious damage? It is needless to go further into the consideration of what might have been done, for enough has been suggested, we think, to show that any wholesale condemnation of fireproof construction, when we consider it in its broad meaning of protective construction against the spread of flame, is not warranted by the Pittsburg fire and its results.

In a closing word attention may well be called to the fact that modern fireproofing systems have never before been subjected to so severe a test as in the Pittsburg fire, nor has it ever before suffered such wholesale destruction by fire. In order that those interested may compare this fire with others in which protective fireproofing has been attacked, we append as a footnote a reference to all such disasters as have been described in Engineering News during the past five or six years.*

## LETTERS TO THE EDITOR.

### How One City Engineer Spent his Salary in Advance.

Sir: Enclosed please find a clipping from the Tiffin "Economist," under date of April 29. Tiffin is a town with a population of about 14,000 inhabitants.

Yours truly,

Fostoria, O., May 10, 1897. F. P. J.

(The clipping is as follows.—Ed.)

At the Monday night session of the city council, Chas. F. Peters was elected city engineer at 40 cts. per hour for all work actually performed. At the close of the meeting, the councilmen, city solicitor, reporters, fire chief and street commissioners enjoyed a banquet at the expense of Mr. Peters, at the Morcher House. The affair was enjoyed very much.

### Central American Rainfall.

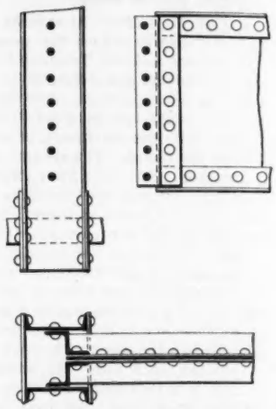
Sir: Having noticed some correspondence in your recent issues referring to excessive rainfall in the arid region, it might be of interest to compare those records with the precipitation, in a comparatively dry year, in a rainy climate. While I was building a railway from Nombre de Dios to the interior, in the interest of the Caribbean Manganese Co., of Baltimore, Md., I kept a daily record of the precipitation in that locality, and I found that during the year 1894 the rainfall was 127 ins. That year was admitted by the natives and residents of the neighborhood to have been an exceptionally dry one. The maximum monthly precipitation was recorded in December, and amounted to 26 ins. The maximum daily record during that month was 6 ins., the greater portion of which fell in 8 hours. During an average year the rainfall will probably be closer to 200 ins. than to the amount we recorded in 1894. The rain gage was kept at Nombre de Dios, a port on the Caribbean Sea, 40 miles northeast of Colon, in the Isthmus of Panama. Yours truly,

Eduardo J. Chibas, Assoc M. Am. Soc. C. E.

Panama, Colombia, April 12, 1897.

### A Simple Floor Beam and Post Connection for Bridges.

Sir: I enclose herewith a blue print of a simple and rigid connection of a floor beam to a post which I have used for several years past on highway bridges. This connection places the load from the beam at the center of the post, and can be used either above or below the lower chord. It is a rigid connection and avoids the objection, if it is an objection, of connecting the beam to the post eccentrically. This connection is not patented, and may be of some interest, perhaps, to some of your readers. Very truly yours,



A Z-Bar Connection Between Floor Beams and Posts in a Bridge Truss.

Henry F. Coleman.

Logansport, Ind., April 21, 1897.

(The connection is so simple that we presume it may have been used by others, but for the information of those who may never have seen it, we reproduce the drawing sent us herewith.—Ed.)

### Suggestions for the Control of Mississippi River Floods.

Sir: Every engineer, in view of the prolonged calamities of the Mississippi basin, must feel that any suggestion is desirable which will tend to promote gradual and effectual remedies for the occasional danger. As a student in river hydrology, an expert in various flood cases and a some time watch engineer and amateur pilot on the main river, I submit the following suggestions in the line of relief:

The Mississippi River is a silt-bearing river flowing, in the 1,150 miles below Commerce, over a deep alluvial bed which it has deposited; with a flood overflow basin, averaging about 60 miles in width, and a direct basin 600 miles long, below Commerce, as compared with the 1,150-mile low stage channel. Its flood flow has been compressed by levees to a channel about 2,300 ft. wide, at different points.

The river has an irregular low stage slope of alternate deep reaches and shallow bars, more or less variable under flood erosion, transportation and deposit. With an extreme flood rise, of 48 to 58 ft. above the Red River, at times of greatest volume, shortest line of descent, and swiftest currents impinging on the concave sides of the bends, it has seriously widened its channel and increased its low stage bar obstructions since the levees were built, and has opened within 18 years, at various times, about 100 miles of flood crevasses above Natchez.

The lateral flood outlet flow through parallel valleys is so great that at Columbus, with about 901,000 sq. miles of basin, a maximum gage of 40.5 ft. gives 1,408,500 cu. ft. per second, while at Carrollton, 955 miles below, with 1,243,750 sq. miles of basin, and a maximum gage of 14.8 ft., the estimated flow is 1,152,504 cu. ft. per second.

Three important lessons seem to be taught by these conditions: The necessity for reducing the extreme flood rise within the levees by properly guarded lateral outlets to the natural relief basins; the necessity for preventing the present flood wave scour along and against the levees by confining the strongest currents to nearly central lines, and to combine this last provision with a regular and continuous self-clearing low stage channel, centrally located, as a controlling flood guide, and a free line of motion in sediment transportation down stream.

To accomplish these results on the river, above Vicksburg, where it begins to change into an arm of the Gulf, the following propositions are submitted: First. Adopt a continuous channel system of low stage section and slopes, to establish a more uniform slope than now exists over the bars and reaches, adjusted to self-clearing action at low stage. Bars with heavy gravel beds should be excavated to the adopted grade for the proper section, with

*Exposure fire, Schiller Building, Chicago, Ill., Eng. News, April 9, 1896; interior fire, Temple Court Building, New York, Eng. News, April 13, 1893, April 9, 1896; interior fire, Athletic Club Building, Chicago, Eng. News, Dec. 1, 1892, April 9, 1896; exposure fire, Manhattan Bank Building, New York, Nov. 14, 1895.

proper side channel levees. Such a low stage continuous channel will not only keep itself clear, but will furnish an adequate silt transportation channel in floods, so as to prevent present serious intermittent deposit here. It will equalize the low water slopes, and by guiding the main flood current will elongate its slope, and thus reduce its velocity, while it restrains impingement on the erosive faces. Such a permanent deep channel guide is, in my opinion, the key to flood control.

Second. To effectually supplement this action, the bed slopes, specially on the concave sides, should be equipped beyond the low stage banks with such structures and obstructions, and the convex side with such relief channels as will not only expand the section adequately to flood rise, but oppose continually increasing resistance to shore current speed, by reducing the depths on the concave sides, and thus the surface velocities. All submerged obstructions are most effective, because they destroy wave force by acting where it has least impinging power, and inshore depth reduction is a potent protective. The dangerous combined increase in river widths and bar obstructions makes this imperative. With the experience now acquired in guiding and changng currents and silt deposit, the river itself can be made to effect much of this improvement; bends can be shortened and broad concave reaches narrowed.

Third. Consistent with the proper concentration of flood flow, within a silt transporting section, a maximum flood flow line should be established in the permanent levees several feet below the known danger line, and the usual crevasse action anticipated and prevented by well-built over-falls, with proper approaches and outlets into the side basins, located at desirable points for relief and outflow; and proper provision made on the parallel valleys to receive, safely control and discharge the surplus.

Fourth. The vast areas in these parallel basins, as cypress swamps, canebrakes, etc., now unfit for agricultural use, should be gradually prepared as relief reservoirs to receive and retain as much of this surplus as is practicable. The advantageous use of this water in low stage navigation, water power, etc., is obvious.

Fifth. On the Ohio and other basins such a reservoir system as that of the Upper Mississippi should be adopted as far as practicable. All river and water supply experience makes this advisable in both low and high stages. That feasible opportunities exist on the head waters of such a formidable flood tributary as the Ohio, my experience and that of other engineers in trunk railway surveys, clearly shows. All that can be done in upper storage and lower relief reservoirs is an essential benefit. Very truly yours,

Samuel McElroy, C. E.

New York, May 13, 1897.

## Determining the Meridian by Observations on the Sun with a Transit.

Sir: Your issues of Mar. 19, May 14 and July 9, 1896, contain interesting and valuable letters upon the methods of determining the meridian by observations on the sun with the engineers' transit and requiring no extra attachment, to a well equipped transit, other than a piece of dark colored glass. The use of these methods, more or less, the past two seasons, has convinced the writer that they should be better understood and more generally used by all surveyors. Surveyors who have no use for a solar compass, and perhaps never have seen one, may easily and quickly determine true bearings with greater accuracy than with the solar compass.

A few points likely to give trouble to the person who may be a bit rusty in practical astronomy have not been clearly explained. To the surveyor accustomed to the use of the solar compass or solar attachments there will be no necessity for such explanation, but I would make the work as plain and as simple as possible for the benefit of those not so familiar with solar work. The constant difficulty arising from surveys referred to the magnetic meridian may be eliminated in the future, if the surveyor will take the time to examine and follow the following method:

1. Observe the sun directly, by the aid of colored glass, and bring his image tangent to the horizontal and vertical wires; read vert. circle and horizontal plates. Suppose that in the first pointing the image was approaching the wires; then bring it into the opposite quarter of the field of view, where the image recedes from the wires; bring the wires tangent and read as before. The mean of these readings will give the apparent altitude and the plate reading for the sun's center. If the transit has a full vertical circle, the telescope should be reversed between the two pointings, to eliminate all errors of adjustment. If the transit has only a vertical arc, no reversal can be made, and great care must be taken that the plate levels and standards are in good adjustment and the index error accurately determined.

2. Read plates when pointing at any convenient mark, thus finding the angle between the sun's center and the mark.

3. Computation of the P Z S triangle enables us to find the angle between the sun and the north; then, addition or subtraction of the angle between the sun and the mark (as the mark is north or south of the sun) gives the angle made by the line (station to mark), and the meridian.

The accompanying form of notes and reductions needs but a few remarks:

The formula

$$\text{Cos } \tfrac{1}{2} \text{ P Z S} = \sqrt{\frac{\text{Sin } \tfrac{1}{2} \text{ S} \times \text{Sin } (\tfrac{1}{2} \text{ S} - \text{Polar Dist.})}{\text{Sin Co} = \text{Alt} \times \text{Sin Co} = \text{Lat.}}}$$

is used because the work of looking out the functions is less liable to error if the functions are all sines.

Some confusion may occur to some readers from the different ways refraction is treated by the correspondents whose letters appeared on Mar. 19 and July 9. The former adds a refraction correction to the declination, as is done in setting the declination arm of the solar compass. The latter subtracts a refraction correction from the observed vertical angle. Both are, of course, correct. The first uses a point which appears to be the sun's center, but is really a point above, and then figures the declination of this point.

Observation.

| Telescope | Horizontal Circle Readings: On Mark | On Sun | Vertical Circle Readings | Date and Time |
|---|---|---|---|---|
| Direct + | 240°41′00″ | 282°51′30″ | 30°57′00″ | Sept. 26th 1896 2.30 P.M. Std. Time 75th Merid. |
| Revd − | 60°41′00″ | 102°43′00″ | 31°09′00″ | |
| Averages | 240°41′00″ | 282°47′15″ | 31°03′00″ | |

Computation.

Declination at Greenwich Noon = 7 A.M. Std. Time 75th Merid. = 1°32′33″ South
Hourly Change = 58″.5. Change for 7½ Hours = 58.5 × 7½ = 7′.39 South
Declination at 2 P.M. = 1°40′12″ South

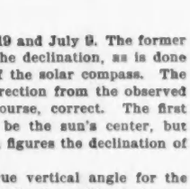
Average Vertical Angle by Observation = 31°03′00″
Correction for Refraction = 1′.40
True Declination = 31°01′20″

Latitude of Thayer School = 43°42′10″
Station about 1 Mile South = 1′.0
Latitude of Station = 43°41′10″

$$\text{Cos } \tfrac{1}{2} \text{ PZS} = \sqrt{\frac{\text{Sin } \frac{1}{2} \text{ S} \times \text{Sin } (\frac{1}{2} \text{ S} - \text{Polar Dist.})}{\text{Sin Co-Alt.} \times \text{Sin Co-Lat.}}}$$

where S = Pole Dist + Co-Alt. + Co-Lat.

Pole Dist. = 91°40′12″
Co-Alt. = 58°58′40″
Co-Lat. = 46°18′50″
S = 196°57′42″
½ S = 98°28′51″
Pole Dist. = 91°40′12″
S − Pole Dist. = 6°48′39″




Log Sin 98°28′51″ = 9.995225
″ ″ 6°48′39″ = 9.074052
a.c. ″ ″ 58°58′40″ = 0.067035
a.c. ″ ″ 46°18′50″ = 0.140781
2 [ 19.277093 ]
Log Cos ½ PZS = 9.638546
½ PZS = 64°12′40″
PZS = 128°25′20″

Azimuth of Sun from North = 128°25′20″
Angle between Sun and Mark = 42°06′15″
Angle North-Station-Mark = 170°31′35″

The second reduces to the true vertical angle for the center of the sun and uses the declination without change. Any point in the heavens, of which the declination is known and the altitude can be measured, would serve as well as the sun's center.

If a single observation is made, as suggested by the writer of July 9th the altitude must be changed by the semi-diameter (16′) and the horizontal angle by, not 16′, but $\frac{16'}{\text{Cos of Alt.}}$. The dihedral angle, whose edge is the vertical line through the instrument subtended by the semi-diameter, varies with the altitude of the sun; from 16′ for Alt. = 0°, to 46′ for Alt. = 69° − 45′ on June 21, in this latitude (43° 42′). I believe this important point has not been mentioned in any of the preceding letters.

An interesting example of the use of these observations occurred this fall during the course of a rapid stadia road survey. The survey enclosed a circuit of about 8.5 miles, along country roads and included the location of all buildings and prominent objects passed. Two parties, going in opposite directions, each completed the survey independently. The first party, having used the needle as a check, came to the starting point with an error of 9′; the second party took sun observations twice each day (survey occupied three days) and ended in error 14′. If the first party had no check, other than the common ones of the needle and the check on the first station, their survey would have been considered fairly good for that class of work. But the true azimuths of six lines along the course, showed that mistakes of readings had been made in four cases, one as high as one degree, and that the three other errors had nearly compensated for the first. These were easily located and the corrected survey closed with the small error of 1 in 680. Although having a solar attachment, the writer has never found it convenient to use upon the ordinary survey, and at best it is subject to so many errors from the many adjustments that it is a poor mechanical solution of the spherical triangle. The method above described introduces no errors, save those common to all transit work, and a little practice enables the triangle to be quickly solved.

Yours truly, A. W. French,
Instructor in Civil Engineering, Thayer School of Civil Engineering, Dartmouth College.

Hanover, N. H., Oct. 9, 1896.

(A formula which is simply a variation of the one given by Prof. French was used for many years by a member of the staff of this journal, for determining the meridian. This formula is the one recommended by the Surveyor-General of Canada for covering township outlines. It is:

$$\text{Cos } \tfrac{1}{2} \text{ z} = \sqrt{\text{Cos S Cos } (\text{S} - \triangle) \text{ Sec } \delta \text{ sec h}}.$$

Where z = the angular distance between the sun and the north point.

$\triangle$ = the distance from the sun to the pole.

$\delta$ = the latitude of the place of observation.

h = the altitude of the sun.

$$\text{S} = \frac{\triangle + \delta + \text{h}}{2}.$$

We are inclined to emphasize the advice given by our correspondent by saying that such observations should always be made with a transit with full vertical circle and with the telescope reversed between the readings.

A further important advantage for accurate and rapid work is a telescope equipped with three cross hairs, one horizontal and the other two making angles of 60° to 70° with the horizontal. We may also note that when the greatest possible accuracy is required in an observation, the altitude should be corrected for parallax.—Ed.)

## Notes and Queries.

J. L. Callanan, of Des Moines, Iowa, inquires whether there is any placer mining done by machinery, other than by hydraulic "giants." If there is, he wishes the address of the builder of the machines. The address is also wanted of men who have tried digging the dirt with steam shovels and then delivering to the sluice-boxes. If any of our readers can answer the queries of our correspondent we would ask them to address Mr. Callanan direct.

## THE CHINESE WHEELBARROW.

At a late meeting of the Institution of Civil Engineers, Mr. Charles Mayne, Assoc. M. Inst. C. E., presented a short paper describing the wheelbarrow which affords one of the chief means of transport in China, and from this paper the following abstract is made:

The Chinese barrow is a decided improvement on the barrows used in Western countries, for it is so constructed that the load is carried directly over the wheel, instead of being between the wheel and the man propelling it. The roads in the northern part of China especially are little more than narrow footways, sometimes paved with blocks of stone, but entirely unfitted for ordinary four-wheeled vehicles. As a consequence both freight and passengers are carried on barrows, the passengers being seated with their backs to the wheel and legs overhanging somewhat after the fashion of travel on an Irish jaunting car.

As described, this barrow has a wheel, 3 ft. in diameter and 1¼ ins. wide on the tire, located in the center of the frame carrying the load. A latticed box covers the wheel and the load is distributed on two braced and latticed steps projecting on each side of the wheel. The wheelbarrow is usually made of oak, has an extreme length of 6 ft. 6 ins., an extreme width of 3 ft. 2 ins., and a height of 3 ft. 6 ins. to top of wheel-frame. It weighs 120 lbs., and the cost of construction, in China, is about $4. Boxes, bales of goods or other freight are securely lashed by rope, and the charge for an average load, depending in weight upon the state of the road, is about 34 cts. per mile. Two passengers on each side, or four in all, are carried at the rate of 4½ cts. per mile for the four. The lower passenger rate is explained by the fact that the freight rate includes loading and unloading, whereas passengers do this work for themselves.

In the foreign settlements of Shanghai this barrow is extensively used for carrying passengers and freight. In connection with the cotton mills there one man will wheel six women a distance of about 3 miles twice a day for 34 cts. per month. About 4,000 licenses are issued per month in Shanghai, for barrows plying for hire, at a monthly fee of 23 cts. But, by the regulations, no barrow is allowed to carry more than 6½ chests of tea, or 8½ boxes of kerosene oil, or 20½ boxes of soap, weighing 30 lbs. each, or 10 boxes of soap, weighing 52 lbs. each. The legal limit of dead weight is 600 lbs. The municipal roads in the foreign settlements of Shanghai are chiefly macadam and the barrow traffic is very severe upon them. Mr. Mayne states that the regulation as to weight is not strictly adhered to as he has seen 50 barrows in a line, each propelled by one man and each carrying two barrels of English Portland cement. Very frequently a load is carried on one side only, requiring unusual skill in balancing and propelling the barrow, but with the result that the edge of the wheel cuts into the macadam like a knife.

## FIREPROOF BUILDING CONSTRUCTION IN THE PITTSBURG, PA., FIRE.

(With two-page engraving.)

We present on our two-page engraving this week a number of views from photographs taken to show the effects of the recent fire at Pittsburg, Pa., upon fireproof building construction. In the accompanying cuts in the text are shown the relative location of the burned buildings and such structural details of their ironwork and floor systems as are especially useful in forming a correct opinion upon the disaster and its bearing upon questions of fireproofing. These illustrations and the information from which the following description has been prepared were obtained during a personal examination of the ruins a few days after the fire by a member of the editorial staff of this journal and by interviews with the engineers, architects, contractors, owners and others whose official connection with the construction of the burned buildings made their evidence of value. In another column some of the suggestions to engineers and architects which the evidence collected seems to offer are briefly discussed, but here the consideration has been confined simply to a plain statement of the facts as found.

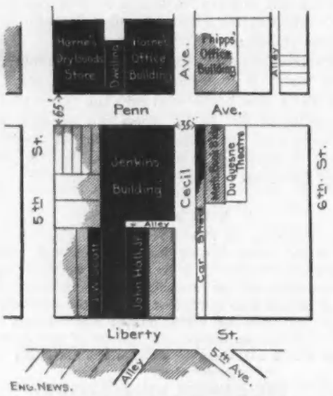



Fig. 1.—Sketch Map Showing Relative Location of Buildings Burned in the Pittsburg Fire, May 3, 1897.

### The Origin and Progress of the Fire.

A plan of the buildings partly or wholly destroyed by the Pittsburg fire of May 3 is shown by Fig. 1. According to the best available information, the night watchman for T. S. Jenkins' grocery store first became aware of fire while making his rounds at 11.45 p. m., but it was some little time before he finally located it in a barrel of paper, rags, scraps from the employees' dinner baskets, and similar refuse, which stood at the bottom of the elevator shaft. For some time—about 15 minutes, as estimated by the watchman—he fought the fire with a chemical fire extinguisher. Finding his efforts to be to little purpose and the flames rapidly ascending the elevator shaft, the watchman sent in a call for the fire department. The engines responded promptly, but so great had been the previous delay that the time of their arrival was 12.20 o'clock a. m. Ten minutes later the flames burst through the windows of the building, and at 12.45 o'clock every floor was burning fiercely, the flames apparently being fed by the large stores of oil, sugar, molasses, hams, etc., with which the building was filled.

The firemen had for some time previous abandoned the hope of saving the Jenkins building and had turned their streams upon the large dry-goods store of Joseph Horne & Co. and the neighboring office building of Durbin Horne. Despite their efforts, however, the woodwork of both these buildings near the tops began to burn at about 1 o'clock, and a few minutes later the flames from the Jenkins building had leaped the street and set fire to the inflammable contents of the dry-goods store windows. At almost the same time the office building began to burn. From this time on the spread of the fire was rapid and a few minutes, according to reports, were sufficient for both the office and store buildings to become a mass of flames so fierce as to drive the firemen from Penn Ave. and Fifth St. to the roofs of the buildings surrounding the fire. From these points of vantage at the rear of the Horne buildings and on the far side of Fifth St., and from the windows of the Methodist Book Building, the firemen directed their streams and prevented the flames from crossing Fifth St. or reaching the rear of the Horne buildings, but the narrower Cecil Ave. was passed. The new Phipps office building was badly scorched, and the Methodist Book Building, above the fourth floor, was completely gutted of its contents.

In approximately two hours from the time of its first discovery, therefore, the fire had destroyed the three larger buildings of the group shown by Fig. 1, a half-dozen smaller structures, and had damaged severely a number of other structures adjacent to the center of the conflagration. To resist its progress the entire fire department of the city of Pittsburg and the neighboring city of Allegheny had been called upon.

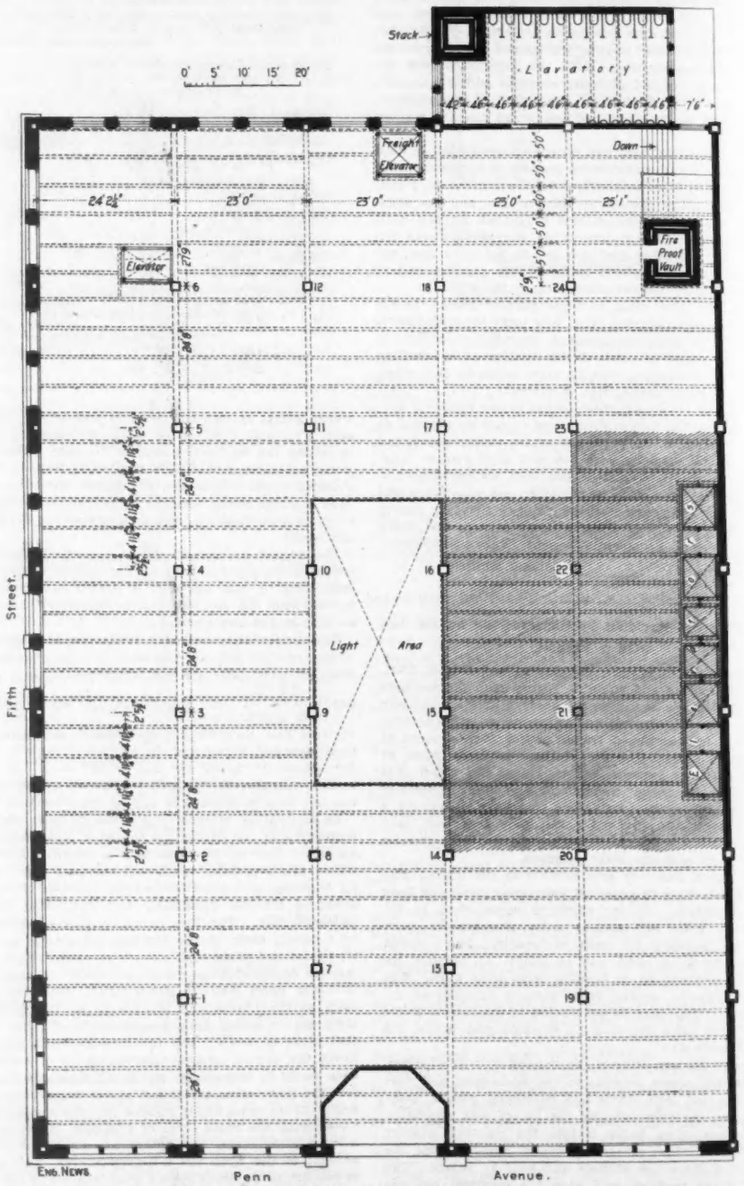



FIG. 2.—PLAN OF THIRD FLOOR OF HORNE STORE, SHOWING NATURE OF STEEL FRAMING.

### The Burned Buildings.

As bearing upon the question of fireproof construction and its behavior when subjected to conflagration, attention need be directed only to the four larger buildings most seriously injured. These are the Jenkins' wholesale grocery, the Jos. Horne & Co.'s dry-goods store, the Durbin Horne office building, and the Methodist Book Co.'s office building. To insure greater clearness each of these buildings will be considered separately.

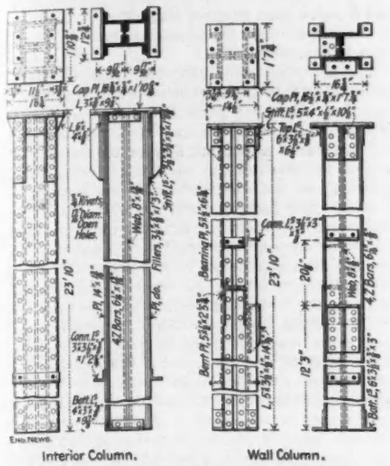
### Jenkins' Grocery Building.

Concerning the construction of this building in which the fire originated very few definite data are available, no records being in existence in the offices of the city's building department and the ruin being so complete as to leave few vestiges of the original construction. Speaking generally, it was of the so-called "slow combustion" construction. The walls were of brick and the floor system of wood flooring and stringers carried on iron I-beam girders. In plan it was L-shaped, with four sides of the L open to the street, and it was six stories high. On the private alley and Cecil alley sides the windows were protected by iron shutters. Each floor was provided with hose and water pipe connections and there were also numerous chemical fire extinguishers available in all parts of the building. The contents of the building were a general line of wholesale groceries and, particularly, large quantities of oils, sugar, molasses, lard, hams, etc., all, of course, exceedingly inflammable materials. The building and its contents were completely destroyed, only a few fragments of the outer walls remaining standing. The falling

of the walls was responsible for the death of one fireman and the serious injury of several others.

### The Joseph Horne & Co. Store.

Construction.—This building was 177 ft 2 ins. × 118 ft. 2¼ ins., c. to c. of wall columns and of modern steel skeleton construction, the walls of each



Interior Column. Wall Column.

**Fig. 3.—Details of Typical Interior and Wall Columns, First Story, Horne Store.**

floor being carried by the steel frame. It had six stories, a basement and an attic, and in front elevation was about 119 ft. from the sidewalk to the top of the cornice. Transversely each floor was divided into five panels by four longitudinal rows of six columns each. At each floor the columns were connected longitudinally by steel girders, which carried the 15-in. I-beam floor stringers spaced 4 ft. 11¼ ins. apart c. to c. Fig. 2 is a plan of the third floor, and Fig. 3 details of typical interior and wall columns between the first and second floors, and Fig. 4 details of typical wall and interior floor girders for the third floor. It will be understood, of course, that the dimensions given in the drawings are accurate only for the members corresponding in character and location to those illustrated, the column sections and other details decreasing as the top of the building is approached. The drawings are given, therefore, simply to show typical constructions. The framework is entirely of steel.

All the steel work was protected by a fireproofing of hard clay tile, the floor arches being 9 ins. deep and sprung between rising skews, as shown by Fig. 5. On top of the tile arches was a sleeper fill of 3 ins. of concrete. The arches were of the side construction type. The column and beam flange protection was also hard clay tile, and its general nature is pretty clearly shown by the views, Figs. 6, 7 and 8. The ceiling between the sixth floor and the attic was of hard clay book tile attached to T-iron. At the rear of the building the windows were protected by wooden shutters covered with sheet iron. Each floor was open throughout and the light and elevator shafts and the stairway were open onto each floor. The front and west sides of the building had very large window areas, as shown by Fig. 9. These windows were not protected in any way from exposure to fire. Extending transversely across the building on the first story and between the rear wall and the sixth transverse row of columns was a balcony.

Effects of the Fire.—Figs. 6, 7 and 8 show interior views of the store taken to illustrate the damage done by the fire. Fig. 6 is a view of the first floor looking toward the southeast corner and showing the wreck of the elevator shaft framing, the first floor columns, and the second floor beams and girders. Fig. 7 is a view looking toward the south end of the building on the third floor and showing the third floor columns, the west building wall and the bottoms of the fourth floor arches. Fig. 8 is a view looking up through the center light shaft and showing portions of the second, third, fourth and fifth floor arches and the book-tile ceiling of the sixth story, and also the adjacent columns. From these views a general idea of the character of the damage done is had, and taking each floor separately the following tabular statement indicates the damage in more detail. The column numbers refer to the numbers given to the 24 interior columns shown on the plan, Fig. 2.

Damage to Column Protection.

First floor:

Col. 1—Tile off entirely for space of about 4 ft., a little above the middle.

Col. 2—Tile broken in places, but column not bare to any extent.

Cols. 3 to 6—Condition about as for column 2.

Col. 7—Tile off entirely for space of about 5 ft., beginning about 1 ft. from the top.

Col. 8—Condition similar to column 7, except that tile is more shattered near the bottom.

Cols. 9 to 12—Tile off from one-half to two-thirds of length, beginning near the tops.

Col. 13—Tile shattered, leaving metal bare in places.

Col. 14—Tile slightly less damaged than on column No. 13.

Col. 15—Tile all off, except about 3 ft. at the bottom; column slightly bent.

Col. 16—Tile all off, except about 2 ft. at the top; column shows a noticeable compound curve.

Col. 17—Tile somewhat shattered at the top, but no metal exposed.

Col. 18—Tile off and metal bare for about 4 ft. on the floor line of the adjacent balcony.

Turning now to the floor arches, the examination of the ruins showed that, between the first and second floors the arches in panels I. and II. were in place and apparently capable of bearing a pretty good load, but the bottom flanges of the arch tiles were broken here and there pretty uniformly over the whole area. The bottom flanges of the girders and stringers also showed bare in numerous places. In panels IV. and V. nearly all of the arches were totally destroyed. On this side of the building were the elevators, and all of the elevator shaft framing and several of the connecting floor stringers were torn out by the fall of the water tank and the debris remained on the first floor, as shown by Fig. 6. The shaded area shown on Fig. 2 indicates the boundaries within which the fall of the tank took out or bent and twisted the floor framing. The damage was not alike on all floors—the fifth and sixth showing the worst effects—but it appeared doubtful if much of the girder work within the shaded area could be saved. On the floors above the second the condition of the arches varied but little from that already described, but if anything was somewhat better. It was noticeable that little destruction of the T-iron and book tile ceiling was caused by the fire, although, of course, the fall of the tank had torn a large hole through the ceilings and dislodged many of the adjacent tile. The condition of the concrete sleeper fill was not easy to ascertain owing to the foot and more of debris covering it, but it was noticed that the sleepers had been burned out nearly clean wherever a place could be cleared and also that the concrete was pretty well disintegrated. It should be stated, however, that this examination was not carried very far owing to its difficulty and also to the fact that a part of one of the arches under study dropped out, leaving a yawning hole at the feet of the examiner, who immediately sought safer though possibly less profitable fields of investigation

Among the more special structural damages to the building were the bulging out of the east wall near the top, the peeling away from the girders of the terra cotta front in places, and the very bad splintering and spalling off of the stone entrances and trimmings on the first story fronts. A particularly notable feature was the action of the wood and sheet iron shutters protecting the rear windows. Except where they had obviously been opened after the fire only one of these shutters was found open, although all were badly warped by the heat. An examination of such as were accessible showed either the sheet iron covering intact or else the inside covering burned away and the wood charred partly through, but the outside sheeting unbroken. Unless all evidence fails, the volume of flame which passed through these shutters must have been confined to such as burst through the crevices due to the warping. As already noted, this rear wall was the boundary of the progress of the fire northward.

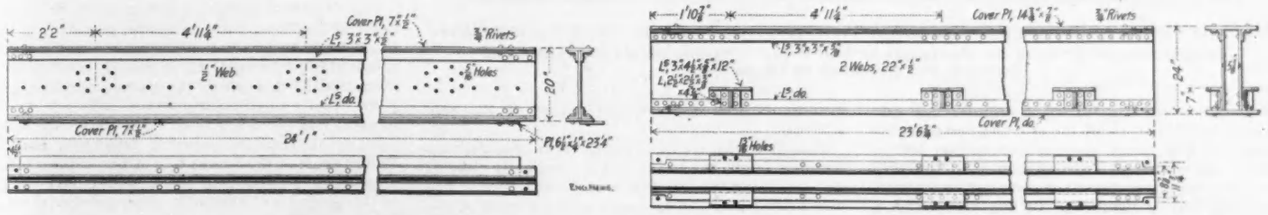


**FIG. 4.—DETAILS OF TYPICAL INTERIOR AND WALL GIRDERS, THIRD FLOOR, HORNE STORE.**

Wall Girder. Interior Girder.

Cols. 19—Tile off for about 8 ft., beginning about 2 ft. from the top.

Col. 20—About two-thirds of the tile off and the remainder badly shattered.

Cols. 21 and 22—Practically stripped of all tile.

Cols. 23 and 24—About one-half of the tile off, beginning near the tops.

Note.—Where the flames from the burning balcony struck the sixth transverse row of columns, the tile for a distance of from 3 ft. to 5 ft. is injured in all cases, and sometimes entirely stripped from the metal.

Second floor:

Cols. 1 to 6—Tile broken in patches, but metal not bare to any extent.

Cols. 7 and 8—Tile shattered and metal bare in spots.

Cols. 9 to 12—About one-third of the tile off on each.

Cols. 12 to 24.—Condition of protection about as for the corresponding columns on the first floor.

Third and fourth floors:

Damage to column protection slightly less than on the second floor, but distributed about the same, and is of about the same general nature.

Fifth and sixth floors:

Practically all the tile is off columns 13, 14, 15, 20 and 22, and on the other columns it is shattered, leaving the metal bare in spots.

It will be noted by observing the location of the various columns that the greater damage was done to the column protection on the east side of the building. Apparently, the fire was most intense on this side from other evidence given further on as well as from this showing, but there also remains to be considered the effect which the falling water tank may have had to displace the tile.

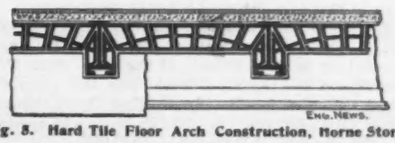


**Fig. 5. Hard Tile Floor Arch Construction, Horne Store.**

Progress and Intensity of the Fire.—The testimony of eye witnesses and the logic of conditions are about all the evidences available to show the

progress of the fire in the building. The fire was communicated from the Jenkins building across the street and about 65 ft. away, and it entered through the windows of the south front, probably being most intense at the southeast corner. It appears to have caught on all six floors at about the same time, and the flames poured up through the center light area and the elevator shaft as through chimneys. There being no partitions, the flames also had full sweep along each floor.

As indicating the intensity of the heat, the debris found in the building furnishes approximate evidence. Practically all of the combustible contents were burned to ashes, although occasional bits of cloth in the center of large rolls, and—at the very rear of the building—the inner leaves of books were found only partly destroyed. On the other hand, a number of cast iron standards for the counter stools were found partly burned or melted away, while the crockery and glassware on the fifth and sixth floors had melted together into a mass. The frames of bicycles were twisted into knots and the saddles, rims and other combustible parts were entirely gone. The view, Fig. 7, shows the nature of the debris left on the third floor, and the appearance of the other floors differed from that of the third in but few respects.

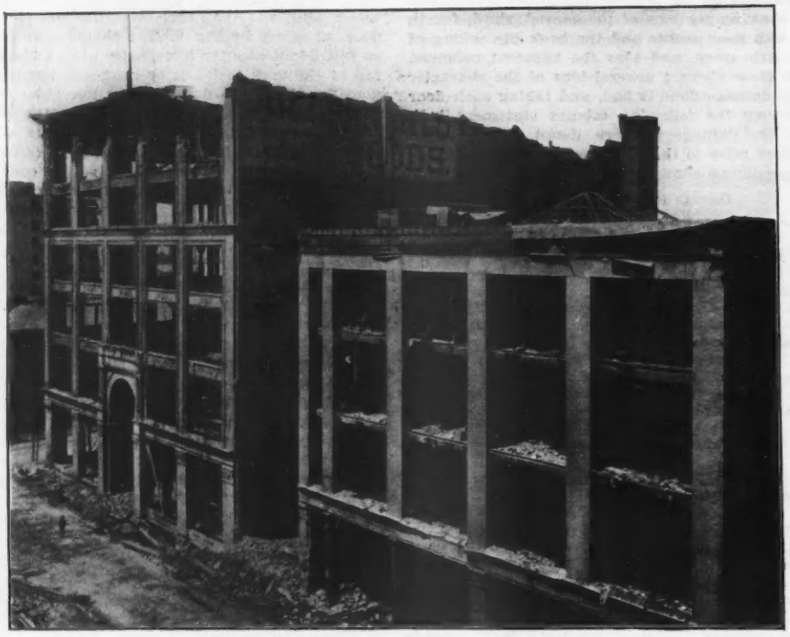


FIG. 9.—VIEW FROM SOUTHEAST SHOWING PENN AVE. FRONTS OF HORNE STORE AND OFFICE BUILDINGS.
Carnegie Steel Co., Pittsburg, Pa., Contractors for Steel Work. Pittsburg Terra Cotta Lumber Co., Pittsburg, Pa., Contractors for Fireproofing.

Estimate of the Salvage.—Probably 80% of the steel work and a considerable part of the outside walls can be saved intact and used as a basis upon which to construct a new building. It would seem that hardly any of the fireproofing could be left standing, for while portions of it may be serviceable they are so scattered that it will be less expensive to fireproof the steel entirely anew.

The Horne store building was designed by the late W. S. Fraser, Architect, of Pittsburg, Pa., and erected by A. & S. Wilson, of the same city. The contractor for the steel work was the Carnegie Steel Co., and for the fireproofing the Pittsburg Terra Cotta Lumber Co. The building was erected in 1894 at a cost, it is stated, of $700,000.

### Horne Office Building.

This building was erected about the same time as the store building adjacent, and the steel frame work is almost identically of the same design, viz.: Z-bar and plate columns, built-up floor girders, and 15-in. I-beam stringers. The fireproofing was of porous terra cotta tile, the floor arches being 9 ins. thick and sprung from rising skews. A 3-in. concrete sleeper fill covered the tile. The end type of floor arch construction was used, and the spans of the arches are 4 ft. 11¼ ins. The rear wall and one side wall of the building were party walls and had no windows, but the front wall and Cecil Alley side wall had windows, as shown by Fig. 9. On each floor the building was divided into offices by 4-in. porous tile partitions, and at the rear were the elevator shaft and stairway. The features of construction chiefly notable in comparison with the construction of the Horne store are the use of porous terra cotta instead of hard tile, and the end system of arch construction instead of the side system.

The fire was communicated from the Jenkins building across the street, and it completely cleaned the combustible materials from every floor. The fireproofing was less damaged near the front of the building, both the floor arches and partitions standing quite well, as shown by Fig. 9. Toward the rear the damage was severe, as shown by Fig. 10, looking upward toward the skylight, and Fig. 11, showing the remains of a number of the 4-in. tile partitions. The first floor rooms, which were used for stores, were open clear to the rear of the building, and there was considerable evidence to show that the flames had passed along these rooms and thence up the elevator shaft and stairway to the rear of the floors above. On the whole the heat appeared to have been slightly less intense in this building than in the neighboring store, although there was probably not such a very great difference. A very considerable part of the fireproofing can be used again and the walls and steel-work are in much better shape than in the store building adjacent.

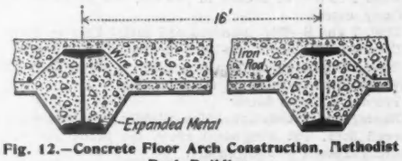



Fig. 12.—Concrete Floor Arch Construction, Methodist Book Building.

### Methodist Book Building.

This building is on the east side of Cecil Alley and is separated from it by a car barn one-story high and about 20 ft. wide. Its total distance from the Jenkins building is approximately 45 ft. The building is rectangular in plan, with its Penn Ave. front and Cecil Alley side divided into offices, which are separated from each other and from the hall, stairway and elevator shaft by metal lath and wooden stud partitions. The floors are concrete arches constructed as shown by Fig. 12, the span being 16 ft. and the thickness of the arch 6 ins., with a 2-in. sleeper fill. The concrete was composed of 1 part Portland cement, 3½ parts sand and 6 parts blast furnace slag. The bottom flanges of the beams were haunched around and wrapped with expanded metal.

The fire was communicated from the Jenkins building and entered the windows of the offices located on the Cecil Alley side. The most of the damage was done above the fourth floor, and in the offices located about midway of the exposed side, neither the rear nor the front offices being so badly injured. In the rooms showing the most intense fire the office furniture and contents were entirely destroyed. On the sixth, seventh and eighth floors, where the damage was greatest, the metal lath and wooden stud partitions were burned through between different offices and between the offices and hallway, the doors and door frames were gone, and the woodwork mostly destroyed. Owing to the fact that there was but little to burn in the hall no great damage was done, but if the conditions had been different the fire could easily have been communicated through the breaks in the partitions. The floor arches were denuded of plaster, leaving the concrete bare. To the structural body of the arches little damage seemed to have been done, although one or two arches showed a slight deflection. In adjusting the insurance two of these deflected arches were condemned. The general appearance of the partitions and floor arches in one of the offices is shown by Fig. 13, which is a fairly representative example of the conditions found elsewhere. The opinions of observers differed as to the comparative intensity of the fire in this and in the Horne store and office buildings, but the evidence of the ruins indicates that the Horne buildings suffered from the greatest heat.

### Other Buildings.

The various buildings adjacent to those already described offered little evidence pertinent to the question of fireproofing, all being of small size and combustible construction. It should be noted, however, that at the rear of the Horne store the Spear Plow Works building, containing large amounts of lumber, was located, while to the east of the Methodist Book Building was the Duquesne Theater. The passage of the flames into either of these buildings, besides destroying them, would have opened to the progress of the fire a large number of small stores and dwellings utterly incapable of affording resistance to the conflagration. The two fireproof structures, however, protected the plow works and the theater from any serious damage, and, as already stated, were the boundaries of the fire in these directions. In the opposite direction, Fifth and Liberty Streets were the boundaries. The total property loss from the conflagration is estimated at $3,000,000, of which the loss on the Jenkins and Horne buildings constitutes the bulk.

For aid in securing the information given here regarding the fire we are indebted to the city officials of Pittsburg, Pa., the Carnegie Steel Co., The Pittsburg Terra Cotta Lumber Co., Mr. Charles Beckel, Architect Methodist Book Building, the various tenants of the burned structures and eye witnesses.

## ELECTRIC TRACTION ON THE NEW YORK, NEW HAVEN & HARTFORD R. R.

The experiments which have been made by the New York, New Haven & Hartford R. R. with electric traction on the overhead wire and third-rail systems at Nantasket and East Weymouth, have resulted in the equipment of a section of the company's line, extending from Berlin to Hartford, Conn., with the third-rail system. The distance is 12.3 miles. From Berlin to New Britain the line is single track, and thence to Hartford it is double track, but only the eastbound track is equipped for the electric system. A separate service is maintained, passengers changing cars at New Britain. The first official trip with the electric cars was made on May 11, under the supervision of Mr. N.

H. Heft, Chief of the Electrical Department of the N. Y., N. H. & H. R. R.

The third-rail conductor is similar to that used on the East Weymouth line, its section being that of a broad inverted V, and its weight being 93 lbs. per yd. It is supported by wooden blocks impregnated with insulating material, the lower edges of the rail being 1½ to 1⅝ ins. above the tie, and the top of the rail being about 1 in. above the track rails. The rails are bonded by 1⅛-in. copper plates, 12 ins. long and 4½ ins. wide. The plates are of 900,000 circular mils capacity, and are fastened under the joints by drop-forged iron angle bars and 16 bolts. No feeders are used, the rail bonds being of sufficient capacity to render feeders unnecessary. There are 22 grade crossings, at all of which the third rail is discontinued, the edges being connected by standard bare copper cables of 500,000 to 850,000 circular mils. These cables are in creosoted wooden conduits filled with an insulating compound and buried in the ballast. The ends of the rails are fitted with wooden incline blocks to raise the contact shoes to the level of the rail head. In order to protect people from injury, the third-rail section is fenced in at the stations, while at the junction at New Britain there is a switchman's tower with a switchboard by which the third rail can be cut out when a train stops at the station and put in circuit again when the train is ready to start.

The equipment at present consists of five open motor cars, each car is 50 ft. long and 32 tons in weight, fitted with air brakes, gongs and a chime whistle. Air for the brakes and whistle is furnished by a vertical double-cylinder air pump driven by a motor controlled by a switch which closes automatically when the reservoir pressure reaches 90 lbs. per sq. in., and opens when the pressure falls below this. The cars were in use last season at Nantasket, but have now had the trolley poles removed. Contact with the third rail is made by cast iron shoes 12×4 ins., 20 lbs. in weight, suspended by links from a beam across the truck frame, flexible cables being used to connect the shoes and motors. The distance between the two shoes is 33 ft., and as many of the grade crossings are wider than this another shoe is fitted to each truck of the second car of the train, so that there is always one shoe in contact with the rail. Each motor car has two General Electric motors and two series-parallel controllers, the cut-out being an automatic circuit breaker fixed beneath the platform hood.

TRAIN OF MOTOR CAR AND ONE PASSENGER CAR.

The power station is a two-story brick building, 113 ft. 3 ins. long, only half the length of the completed building having been thus far erected. In the rear is the boiler room, with ten tubular boilers of 300-HP. each, arranged in two batteries. They were built by G. E. Kendall & Sons, of Cambridgeport, Mass., and the fronts can be taken down without disturbing the rest of the boiler setting, the front being bolted to a plate on the wall instead of to the wall itself. This is the device of Mr. N. H. Heft. The feed is supplied by two pumps, and there is a brick smokestack 125 ft. high. The completed building will eventually have six engines, but at present only one has been installed. It is a Greene-Corliss cross-compound, condensing engine, with cylinders 28, 48 and 48 ins. diameter and 4-ft. stroke, rated at 1,200-HP. when running at 100 revolutions per minute. It was built by the Providence Steam Engine Co., of Providence, R. I. The engine is directly connected to one of the General Electric Co.'s 10-pole 850-volt generators of the ironclad type. It is over-compounded and furnishes current at 650 volts with full load and 600 volts with no load. The switchboard has seven panels, only three of which are yet fitted up. Two are generating panels, having automatic circuit breakers, magnetic blow-out, ammeter, and the usual panel equipment. The third panel is fitted with a Thomson recording Watt-meter showing the total output from the generator. A traveling crane with two trolleys, of 35 and 5 tons capacity, extends the length of the engine room. This was built by the Berlin Iron Bridge Co., of East Berlin, Conn., which company furnished the steel roof trusses. From the switchboard four cables, each of 850,000 circular mils section, extend to the third rail.

TRUCK OF MOTOR CAR; N. Y., N. H. & H. R. R.

## SOFT OPEN-HEARTH STEEL FOR BRIDGES.

Mr. A. C. Cunningham, M. Am. Soc. C. E., of the firm of Stowell & Cunningham, civil engineers, Albany, N. Y., sends us the following records of tests recently made by him of acid open-hearth steel which was made by the Phoenix Iron Co. to fill a large order. The steel is to be used in railway bridges. The chemical and physical characteristics of the steel show that it is equal to the best boiler-plate steel. The tests were made on angles varying in size from 3½ × 3½ × 7-16-in. to 5 × 3 × ⅜-in.

| Cast No. | 1,474 | 1,475 | 1,476 | 1,477 | 1,478 |
|---|---|---|---|---|---|
| Carbon | 0.10 | 0.10 | 0.10 | 0.11 | 0.11 |
| Phosphorus | 0.015 | 0.051 | 0.046 | 0.049 | 0.052 |
| Manganese | 0.35 | 0.30 | 0.35 | 0.38 | 0.35 |
| Sulphur | 0.035 | 0.034 | 0.040 | 0.039 | 0.038 |
| Elastic limit | 39,670 | 40,520 | 38,740 | 39,570 | 38,910 |
| Ultimate strength | 59,920 | 58,840 | 58,380 | 60,220 | 58,650 |
| Elong. in 8 ins. % | 29.5 | 28.0 | 31.0 | 28.7 | 31.0 |
| Red. of area % | 61.4 | 62.1 | 65.4 | 59.8 | 67.4 |

The results of the tests of this steel show such an unusually soft quality, while there is at present a tendency among some bridge engineers to use a harder steel, that we wrote to Mr. Cunningham for further information concerning it, and he replies as below:

The steel is noticeable on account of the low phosphorus and sulphur in acid open-hearth steel. I think you will search ineffectually in general test reports for anything equalling it.

Sixty tons of this steel was made under Mr. Geo. H. Thomson's specification, which for completeness of detail I am not aware has been surpassed.

Two hundred tons was made under a specification prepared by our Mr. Stowell, assisted by myself. The essentials of the specifications are as follows:

Acid open-hearth steel: Ultimate strength, 55,000 to 65,000 lbs.; elastic limit, ½ of ultimate strength; elongation in 8 ins., 25%; reduction of area 50%. Fracture to be free from indications of bad heat treatment and working; cold, hot and quenched trend-flat. Drift test, 50%.

Cast analysis to show not more than 0.07 phosphorus and 0.04 sulphur. Check analysis on finished material not to indicate a segregation of more than 50% on the cast analysis.

The securing of these requirements is indicated in detail, and the result has justified the effort. The tendency towards harder steel for structures has been observed by us, and is watched with interest. If its advent is gradual, it will doubtless meet with success; but if any sudden jump is made, we look for trouble. Basic open-hearth steel, which is slowly but surely creeping into all structural work, is at its best in the softer grades. Attempts to harden it must be made almost entirely by recarburization, and, until the general processes for this are more perfect and more under control, non-uniformity must result.

The general shop practice to-day is adapted to soft and medium steel, which may greatly injure hard steels, and any sudden change in hardness of steel will not find a corresponding change in the education of the workmen who handle it.

## NOTES FROM THE ENGINEERING SCHOOLS.

Massachusetts Institute of Technology.—Summer school courses will this year be given in civil engineering, mining engineering and architecture.

The summer school in civil engineering will be located at Machias, Me. The course will include the completion of the topographical survey begun last year, the continuation of hydraulic measure-

ments, the rating of the current meters and tidal observations to be made with a new form of tide gage. A hydrographic survey of Howard Bay will also be made, and probably some new work will be carried on concerning the measurements of variations in atmospheric refraction. This school, which is intended only for students at the close of their third year, will begin on June 8, and will close on July 1, 1897. It will be under the charge of Prof. Burton.

The summer school of mining engineering and metallurgy this year will be in charge of Associate Professor Hofman, and will continue for about three weeks, beginning not later than June 9. The places visited will include Port Henry, Troy, Syracuse, Buffalo and Niagara Falls in New York, and Cleveland, Ohio. The special processes to be studied will be the metallurgy of iron, steel, and copper, the manufacture of coke with the saving of by-products, and the manufacture of soda and carborundum.

The summer school of architecture will be held at Quebec, the course to be for three weeks, beginning June 8. Professor Homer will have charge of the party. The work to be accomplished includes sketching both in pencil and water color.

Purdue University.—A new experimental locomotive has been ordered by the University from the Schenectady Locomotive Works. It will take the place in the engineering laboratory, which has for the past six years been occupied by the old locomotive, known as "Schenectady No. 1," and which has run for experimental purposes, while resting on a dynamometer, an amount equivalent to 20,000 miles. The old locomotive will pass into active service on the road within the present month and the new one will be delivered early in the fall. Professor W. F. M. Goss, director of the engineering laboratory of Purdue University, under whose direction the experiments on the old locomotive have been made, gives us the following particulars concerning the new engine:

The locomotive will possess a number of features which are quite new. It will carry a steam pressure of 250 lbs. and will have cylinders so arranged that it may be used as a simple or a compound. The cylinders and the saddle will be made up of different castings and the centers will be so chosen as to allow the use of cylinders up to 30 ins. in diameter. Several cylinders will be provided, and these, with a suitable series of bushings, will allow for different cylinder ratios in compound work. The whole machine will thus afford facilities for dealing with conditions quite beyond the limits of present practice.

A large amount of data derived from Schenectady No. 1 during the past year will soon be issued from the laboratory, and as soon as practicable all of the papers descriptive of work accomplished in connection with this engine will be published in a single volume.

Michigan College of Mines.—A bill has been passed by the legislature changing the name of the Michigan Mining School to the Michigan College of Mines.

A bill regarding the charging of tuition has also been passed, fixing the rate at $25 for residents of Michigan, and not less than $50 or more than $200 for those residing outside of Michigan. The exact rate has not yet been determined by the Board of Control of the college; in all probability it will be fixed at $150 for non-residents of Michigan. This tuition fee will correspond with that charged by other first grade technical schools in America, such as Columbia College School of Mines, the Rensselaer Polytechnic Institute, the Stevens Institute of Technology, and the Massachusetts Institute of Technology.

When the school was working out its policy it was thought wisest to charge no tuition, but to collect as wide a constituency as possible. It was also deemed hardly just to the students educated here to demand tuition until the institution was much better equipped for its work than the appropriations granted during the first decade of its existence permitted. Now that success has been attained in educating men for practical work, as is evidenced by the positions which its 86 graduates hold, a list of which is given in the last catalogue, the institution seems warranted in charging hereafter for its instruction.

The new law goes into effect immediately after August 19, 1897, and will therefore not apply to students entering previous to that time.

A prospectus will soon be issued by the college giving the details of the regulations finally adopted by the Board of Control.

WILLOWS ARE TO BE RAISED ON SEWAGE FILter beds at Ripon, England, according to the London "Contract Journal." Ripon is a town of about 10,000, which has just prepared twelve acres of sewage filters, with three rows of underdrains placed beneath pathways. The beds have been leased for ten years to a firm of willow growers at about $5 per acre per year. The town takes care of the sludge gathered in a small sludge pit, designed to remove the coarser materials from the sewage, but aside from this the lessees are to distribute the sewage and care for the beds under the supervision of the City Surveyor, Mr. W. Edson.

ONE OF THE TWO CAISSONS for the New York tower of the new East River bridge was successfully launched in Brooklyn, N. Y., May 15, at 7:51 a. m., after an unsuccessful attempt on May 13. The caisson was on greased ways, and was started by hauling with three tugs and pushing with two 30-ton jacks. It is 60 × 76 ft., 19 ft. high, with a coffer dam extending 12 ft. along the top, and its weight 1,100 tons. The caisson is of southern yellow pine, with a steel cutting edge, and the corners are also sheathed with steel. It will be sunk in 20 ft. of water, but the bed rock to which it must be sunk is 60 ft. below the surface, the work being done by the pneumatic process. The work was done by Mr. P. H. Flynn, the contractor, under the supervision of Mr. L. L. Buck, M. Am. Soc. C. E., Chief Engineer of the East River Bridge Commission.

THE GALOPS-PRESCOTT CANAL, on the St. Lawrence River, is to be built by the Cleveland Bros., of Brockport, N. Y., for a sum aggregating about $750,000. This canal, of which mention has already been made, will run direct from the head of the Galos Canal to a point near Prescott. It will be 2½ miles long, 200 ft. wide on the bottom and have a depth of 17½ ft. In involves about 120,000 cu. yds. of submarine rock excavation and 400,000 cu. yds. of earth dredging, according to the "Times," of Watertown, N. Y. The Cleveland Bros. have been long engaged in contract work in connection with the enlargement of the Canadian canal system, and they have been enlarging the Galops canal for the last seven years.

THE NEW VICTORIA BRIDGE over the St. Lawrence River at Montreal, which was mentioned in our last issue, will have truss spans of the same length as those of the present tubular bridge, but the new bridge will be wider than the present bridge, which has only a single track. The new bridge will have two tracks between the trusses, which will be used for trains of the Grand Trunk Ry. and the electric cars of the street railway company. The cantilever ends of the floor beams will support two roadways outside the trusses, with a sidewalk outside of each roadway.

A STEEL LEVEE CORE has been devised by Mr. M. H. King, of Des Moines, Ia. He proposes to drive a line of piles on the axis of the levee, with the heads capped just below the natural surface of the ground. Upon this cap he would erect a riveted wall of thin steel plate, stiffened by angle-bars and extending almost to the crown of the levee. This continuous steel sheet would be anchored back at intervals by rods extending from the top and passing to flat anchors buried in the rear slope. He claims that this sheet of steel will prevent the land side of the levee from becoming water-soaked or weakened by the action of water or the burrowing of animals. He estimates the cost of the piling, capping, steel plate and anchors at about $5,000 per mile, and figures that the 2,000 miles of Mississippi levees could thus be made tight for about $10,000,000. He says nothing about the means of preserving the metal from oxidation.

THE CONTRACT FOR THE CHINESE RAILWAY, proposed between Pekin and Hankow, a distance of 1,200 miles, is made a subject of a special commission, to be sent from Belgium to China. The parties seeking this contract are Belgian manufacturers, but the King and his Ministers are said to be interested in it.

THE CATARACTS OF THE NILE may be utilized commercially for furnishing electric power, according to the opinion of Prof. George Forbes, who has recently made an examination of the subject in Egypt. He considers that by means of electric power, irrigation could be exceeded and cheapened, and that the power would be available all the year for working railways, cotton gins, sugar factories, etc. He expects to make a complete survey in September and to present the government with a project for utilizing the power.

A STEEP GRADE ELECTRIC RAILWAY is projected up the Cote des Nieges hill, at Montreal, with an auxiliary cable and counter-weight for purposes of safety. The steepest grade is 12%, and the system proposed is similar to that on the College Hill line, at Providence, R. I., which has grades of 7½% to 15%. Ascending cars are assisted by the descent of the counter-weight in the cable conduit, while descending cars are retarded by having to pull the counter-weight up the incline.

STREET CARS WILL BE RUN ON SUNDAY in Toronto hereafter, the proposition having been carried at the polls by a majority of 479 out of a total vote of 12,987. Under the franchise of the street railway company no Sunday cars were to be run unless voted for by the citizens, votes to be taken not oftener than once in three years. About seven years ago Sunday cars were voted down by a majority of over 2,000, and again some four years ago by 900 majority. The interest in the last campaign is shown by the fact that over 33,000 voted on the question. The population of Toronto in 1891 was 181,220. The introduction of Sunday cars will considerably increase the revenue which Toronto derives from its street railways, as the city receives a large percentage of the gross receipts.

THE EXTENSION OF THE SUTRO TUNNEL is proposed as a means of draining the claims of the American Flat Development Company. The extension would commence at the Alta mine, and the work is to be done by contract; and as the contract would be a large one a number of corporations are after it. Prominent among these are the Sutro Tunnel Company and the Comstock Tunnel Company, both of which believe that they are favorably equipped for doing the work rapidly and cheaply. The transmission of electric power from Carson City to Sutro and thence into the tunnel is already under consideration. This power would be used for transport, ventilation and drilling.

THE BLACK SEA AND BALTIC CANAL SCHEME is being revived on the general lines laid down by Emperor Alexander III. six years ago. Plans and general specifications were made three years ago by M. Emile Flourens, but the death of the Emperor caused them to be laid aside until now. The route proposed is from the Gulf of Riga, on the Baltic Sea, along the rivers Duna, Beresina and Dnieper to Khersun, on the Black Sea, northwest of Sebastopol. The length of the route would be 994 miles, and a depth of 28 ft. is proposed, at an estimated cost of $100,000,000. The chief incentive in building such a canal would be the military advantages of connecting these two seas; but it would also develop a rich tract of country, producing corn, timber, iron, salt, etc. As indicating the engineering difficulties to be overcome it may be said that the River Duna is 650 miles long, and in the first 90 miles from the mouth rises 280 ft. above sea level and reaches an elevation of 511 ft. at the summit. At the latter point it would connect with the Beresinki Canal constructed in the last century and join the Dnieper at an elevation of 385 ft. The Dnieper is 1,000 miles long, drains 204,000 sq. miles and discharges into the Black Sea by nine mouths with not more than 10 ft. of water in the deepest channel. About 200 miles from the mouth rapids, with a total fall of 107 ft., extend over 40 miles of the river's course. The engineering difficulties to be overcome are evidently great.

THE FIRST OMNIBUSES, or vehicles for public transport of passengers, in Paris, says the "Economiste Francais," made their appearance in 1662, and Pascal was one of the promoters of the scheme. They were in use for several years, but they were not intended for the common public, as the law forbade their use by "soldiers, pages, lackeys or other people in livery, and workingmen." No attempt was made to further introduce this class of vehicles until 1819, when a request for authority to establish such a system appears. But it was not until 1828 that a M. Baudry received permission to establish a system of omnibuses in Paris and operated the first line between the Bastile and the Porte Saint Martin. Shortly after this time 100 omnibuses were running, each drawn by three horses abreast and carrying 14 passengers. Other lines were soon established and the system of "correspondence," or gratuitous exchange, was inaugurated in 1840. Finally, in 1860, the Compagnie Generale des Omnibus was organized and obtained from the city of Paris the exclusive concession to transport passengers within the city limits until 1910, except in some special cases.

THE METRIC SYSTEM of weights and measures is recommended for adoption by all departments of the U. S. government, in House bill 1,058, introduced on March 19, 1897, by Congressman Hurley. This bill proposes to make the metric system the legal system of weights and measures recognized in the United States, after July 1, 1900, in the transaction of all business requiring the use of weight and measurement, except in completing public land surveys. The bill was referred to the Committee on Coinage, Weights and Measures, and ordered to be printed. The Illinois Society of Engineers and Surveyors, at its late annual meeting passed resolutions advocating the exclusive use of the metric system at or soon after the beginning of the new century.